

















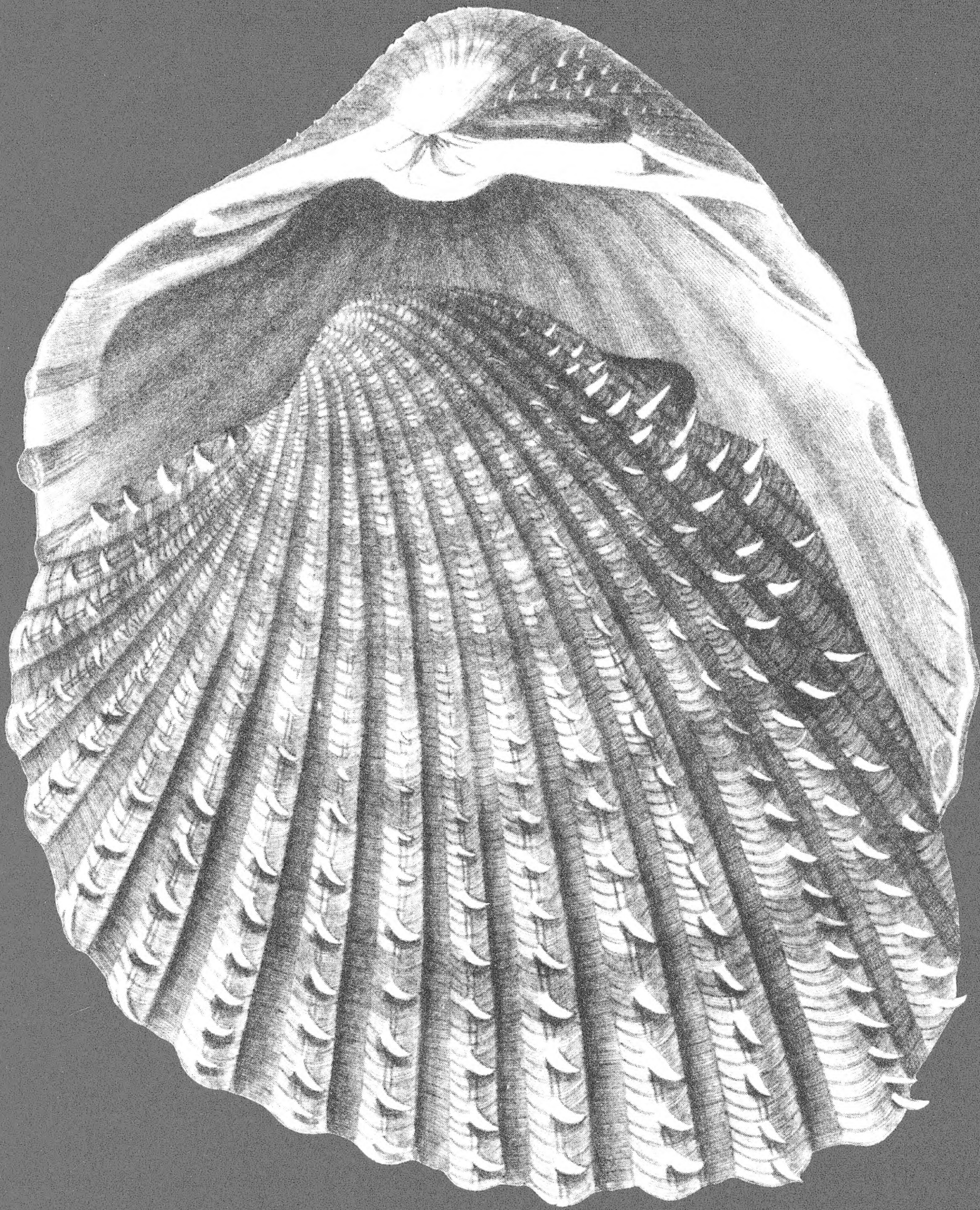
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ISSN 0022-0019

# Journal of Conchology

(Established 1874)

Vol.38, Part 4, December 2004



*promoting* Conservation,  
Biogeography and Taxonomy



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Printed by Henry Ling, The Dorset Press, Dorchester DT1 1HD





## EDITORIAL

### A PROTOCOL FOR THE PUBLICATION OF DISTRIBUTIONAL RECORDS OF ENDANGERED SPECIES

The *Journal of Conchology* has a distinguished history of publishing distributional data, primarily but not exclusively, concerning British and European Mollusca. The Society has played a major role in molluscan conservation and its contributions continue. Today, in Europe such activities have culminated in national and European Union legislation for the protection of many molluscan species. In addition considerable resources have been allocated to ensure their continued survival. Such conservation measures are often seen to conflict with other interests such as agriculture, industry and leisure pursuits. As a consequence data on endangered species have become both critical but also sensitive. In my own experience with the Freshwater Pearl Mussel there has been considerable debate over the publication of sites due to the possible increased exposure to pearl fishing. The destruction of sites holding endangered species by land owners not wishing to have their land scheduled has also been experienced in some countries. The concerns over distributional data of critical species bring a higher degree of responsibility to potential publishers and as a result The *Journal of Conchology* is introducing a protocol for the publication of distributional data of species carrying national or European Union protective legislation. This protocol is being attached to instructions for authors. Protocol for the Publication of Distributional Records of species carrying national or European Union protective legislation.

Authors of papers, communications and records on the distribution of species listed in national and European Union protective legislation should before submission to the *Journal of Conchology* ensure the following:-

- A. That any relevant permissions and licenses were obtained and are acknowledged.
- B. That data have already been forwarded to the relevant national conservation agency.
- C. That the relevant national conservation agency has no objection to the publication of such data.

The Editor of the *Journal of Conchology* retains the right to independently confirm compliance with this protocol, and this will be achieved through the normal peer review process.

The formulation of this protocol is not solely intended to protect the *Journal* but is to a greater extent an encouragement for individuals and societies to work together to further the protection of these species. The sharing of data is an essential part of the process and is of critical value to conservation agencies. Distributional data is far from complete for many species and the activities of recorders and researchers have and remain invaluable sources.

Dr Graham Oliver  
Honorary Editor





# RECENT DEEP-SEA SPECIES OF *BENTHONELLANIA* LOZOUET, 1990 (GASTROPODA: RISSOOIDEA) FROM THE SOUTH-WESTERN ATLANTIC, WITH DESCRIPTIONS OF TWO NEW SPECIES UTILIZING A SHELL MORPHOMETRIC-MULTIVARIATE APPROACH

RICARDO SILVA ABSALÃO<sup>1,2</sup> & FRANKLIN NOEL SANTOS<sup>1</sup>

*Abstract* Two new species of *Benthonellania* are described and the first record of *Benthonellania donmoorei* Moolenbeek & Faber, 1991 is reported from Brazil. *Benthonellania coronata* n. sp. has less axial ribs than any other congener, absence of spiral sculpture and relatively strong nodules at adapical end of axial ribs. *Benthonellania multicostata* n. sp. has numerous opisthoclinal axial ribs, no trace of adapical nodules and convex whorls profile. Multivariate conchological analysis (Cluster and Principal Component Analysis) of the two new species as well as *Benthonellania xanthias* (Watson, 1886) confirm the species status for the two new taxa. *Alvania colombiana* Romer & Moore, 1988 is confirmed to the genus *Alvania*.

*Key words* *Benthonellania*, *Rissoidea*, *Rissooidea*, deep-sea, bathyal, Brazil, morphometry.

## INTRODUCTION

In spite of recent efforts by several South American malacologists, knowledge of the marine malacofauna off most of eastern South America is still far from satisfactory. With regard to deep-sea molluscs, regional investigators historically have had limited access to abyssal depths. In the last decade, the Brazilian federal government established a program of biological surveys covering the entire Brazilian outer continental shelf and slope, according to recommendations contained in the "United Nations Convention on the Law of the Sea" and with the view of securing data on a 200-mile exclusive economic zone for the country (REVIZEE Program). Concurrently, Petrobras (the Brazilian Petroleum Company) intensified its marine survey activities, especially in the deep-sea off the coasts of the states of Rio de Janeiro (Campos Basin Deep-sea Environmental Project – PETROBRAS) and Sergipe (Sergipe Basin Characterization Project – Petrobras Co.). In response to the requirements of public agencies for environmental control, Petrobras is developing a broad program of environmental characterization of present or potential petroleum production areas. Both actions, by Petrobras and by the Brazilian government, have resulted in the collection of a number of samples with previously unknown molluscs from deep waters off Brazil, among them the many specimens of *Benthonellania* spp.. Previously to these Brazilians projects, in 1987, the French Research Vessel Marion Dufresne carried out a campaign at Southern coast of Brazil where 67 deep water stations were performed and additional material were obtained. Part of these material were the subject of this study.

The genus *Benthonellania* was established in 1990 by Lozouet to accommodate 5 species (3 recent and 2 fossil) from the Atlantic Ocean. At that time, only *B. xanthias* (Watson, 1886) was known to occur in the western Atlantic. In 1991, Moolenbeek & Faber described *B. donmoorei* from Barbados, and suggested that *Alvania colombiana* Romer &

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Moore, 1988 should be transferred to this genus. In 1993, in their monographic work on bathyal and abyssal Northeastern Atlantic gastropods, Bouchet & Warén allocated *Rissoa fayalensis* Watson, 1886 to the genus *Benthonellania* and described two additional species, *B. oligostigma* and *B. agastachys*. In 1999 Gofas report about *B. gofasi* at Eastern Africa. No report on *Benthonellania* has appeared since then.

#### ABBREVIATIONS USED THROUGH THE TEXT:

IBUFRJ – Instituto de Biologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro; MNHN – Muséum National d'Histoire Naturelle, Paris; MNRJ – Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro; MORG – Museu Oceanográfico “Eliézer de Carvalho Rios” da Fundação Universidade do Rio Grande, Rio Grande; MZSP – Museu de Zoologia, Universidade de São Paulo, São Paulo; DOUFPE – Departamento de Oceanografia, Universidade Federal de Pernambuco; REVIZEE – Recursos Vivos da Zona Econômica Exclusiva; CBDER - Campos Basin Deep-sea Environmental Programme – Petrobras; SBSP- Sergipe Basin Deep-sea Project– Petrobras; Rv MD55 - Research Vessel Marion Dufresne; AG – Supply Boat “Astro Garoupa”; stn- oceanographic station.

#### MATERIAL & METHODS

The material examined proceeds from several oceanographic stations from Sergipe, Bahia, Espírito Santo and Rio de Janeiro states. In the lists of material, number inside brackets indicate number of shells. Only dead collected shells were obtained. Besides the species herein described, others species from the same family were examined for comparasons.

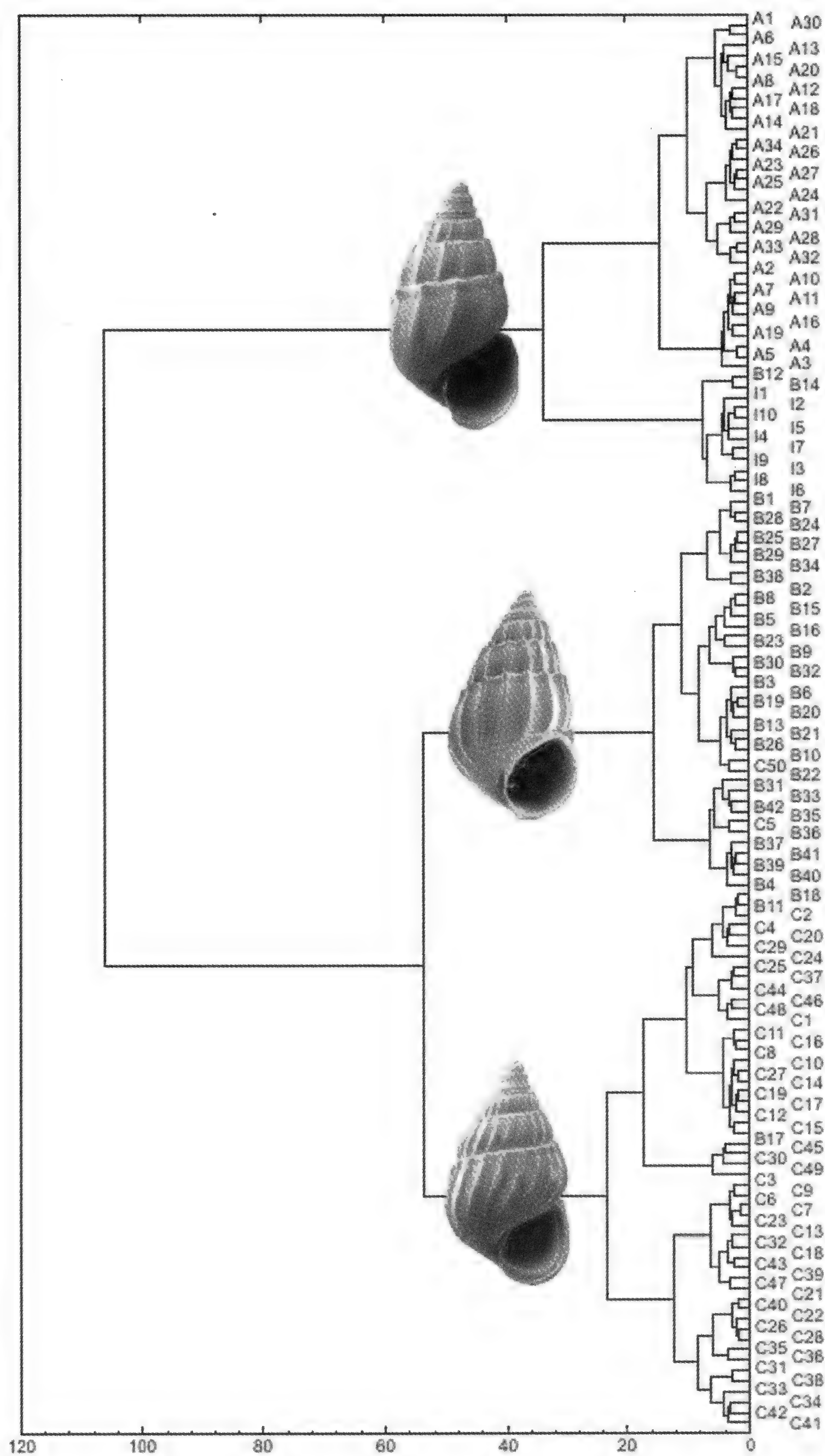
REVIZEE (AG coll.): stn 25 A, 19°33'20"S, 38°45'20"W, 230 m, 28/vi/2001; stn 41F, 20°29'57"S, 29°16'14"W, 360 m, 10/vii/2001; stn 504, 14°28'50"S, 38°54'01"W, 278 m, 02/vii/2001; stn C13, 16°47'47"S, 38°25'51"W, 247 m. South of Bahia, Brazil, 19/vi/2002; stn 1F, 13°04'48"S, 38°21'19"W, 830 m, 03/vii/2001; stn A3, 18°30'00"S, 37°42'20"W, 260 m. South of Bahia, Brazil, 26/vi/2002; stn 52C, 21°45'52"S, 40°04'52"W, 450 m, Rio de Janeiro, Brazil, AG col.; 21/vii/2001.

PCABS (AG coll.): stn 3.3, 11°28'43"S, 37°10'58"W, 184 m, 21/iv/2002; Stn 1.3, 11°14'54"S, 36°59'46"W, 128 m, 23/iv/2002; stn 2.1, 11°23'21"S, 37°04'30"W, 99.5 m, 16/iv/2002; stn 2.2, 11°23'48"S, 37° 04'48"W, 90.5 m, 16/iv/2002; stn 5.3, 11°24'44"S, 37°03'35"W, 500 m, 17/iv/2002; stn 9.2, 11°30'08"S, 37°07'56"W, 1031 m, 19/iv/2002; stn 12.1, 11°31'53"S, 37°04'42"W, 1347 m, 19/iv/2002.

CBDSEP (AG coll.): stn 4, 21°58'18"S, 39°50'40"W, 1350 m, 05/x/2001; stn 45, 22°10'54"S 39°52'19"W, 1050 m, 10/xii/2002; stn 57, 21°57'5"S, 39°47'43"W, 1650 m, 10/xii/2002; stn 60, 21°52'50"S, 39°51'42"W, 1050 m, 12/xii/2002; stn 77, 22°36'03"S, 39°57'67"W, 1750 m, 16/xi/2002; stn 80, 22°24'31"S, 39°57'28"W, 1094 m, 20/xi/2002; stn 84, 22°26'27"S, 39°58'64"W, 1099 m, 20/xi/2002; stn 85, 22°29'33"S, 39°56'17"W, 1395 m, 19/xi/2002.

MD55 (Rv MD coll.): stn DC75 18°59'S, 37°50'W, 295 m, v/1987; stn DC70, 18°59'S, 37°48'W, 1540-1550 m, v/1987; stn DC72, 19°00'S, 37°49'W, 950-1050m, v/1987; stn CB104, 23°42'S, 42°06'W, 430-450 m, South of Cabo Frio, Rio de Janeiro, Brazil, vi/1987; stn CB76, 18°59'S, 37°50'W, 637 m, v/1987.





**Fig. 1** Dendrogram Hierarchical representation of morphological similarities among *Benthonellania* taxa. Ordinate as Linkage Distance measured as Euclidean distances and Ward's methods of clustering. Abscissa as specimens. A= *B. coronata* n.sp.; I= *B. cf. coronata*; B= *B. xanthias* and C= *B. multicostata* n.sp.

## MORPHOMETRIC ANALYSIS

Although we could discern clear differences among the *taxa* as represented by their SEM photos (figs 3-5), the natural variability within each *taxon* makes it difficult to assign some individuals satisfactorily. In order to minimize the subjectivity of the taxonomic process, we decided to attempt to discriminate among our *taxa* through a multivariate morphometric analysis. We randomly chose 42 specimens, among the best preserved ones, of *B. xanthias* (herein named sp. B), 34 of *Benthonellania* sp. A, 10 of *Benthonellania* cf. A, and 50 of *Benthonellania* sp. C. Each specimen was drawn with the aid of a camera lucida. The following conchological variables were measured and/or calculated: 1 – proportion of height/width of shell (H/W), 2 – proportion of height/width of aperture (Ha/Wa), 3 – number of whorls in protoconch (NPW), 4 – protoconch height (PH), 5 – spire angle (SA), 6 – increment of teleoconch whorl width between first and second whorl – rate of whorl expansion (TWEx1-2), 7 – increment of teleoconch whorl width between second to body whorl (TWEx2-3), 8 – number of axial ribs in first teleoconch whorl (NAR1), 9 – number of axial ribs in second teleoconch whorl (NAR2), 10 – number of axial ribs in body whorl (NAR3), 11 – variation in number of axial ribs between first and second whorl (VNAR1-2), 12 – variation in number of axial ribs between second and body whorl (VNAR2-3), 13 – number of cords on the base (NCB), 14 – base width (BW), 15 – arco length (AL), 16 – arco angle (AA).

We performed a preliminary analysis of the correlations among all pairs of variables, to avoid considering strongly correlated variables together. Next, the data matrix was standardized by subtracting each value from its median, and dividing by its standard deviation (Romesburg, 1984). This standardized data matrix was submitted to Cluster Analysis utilizing Euclidean distance as a measure of dissimilarity and Ward's method of clustering (Romesburg, 1984). The same data set was also submitted to an ordination technique (Principal Coordinates Analysis – PCA), to search for possible continuities among the data. Differences in the scores on the PCA axis were tested for significance by the Mann-Whitney U-Test (Steiner & Linse, 2000; Nemeschkal, 1999).

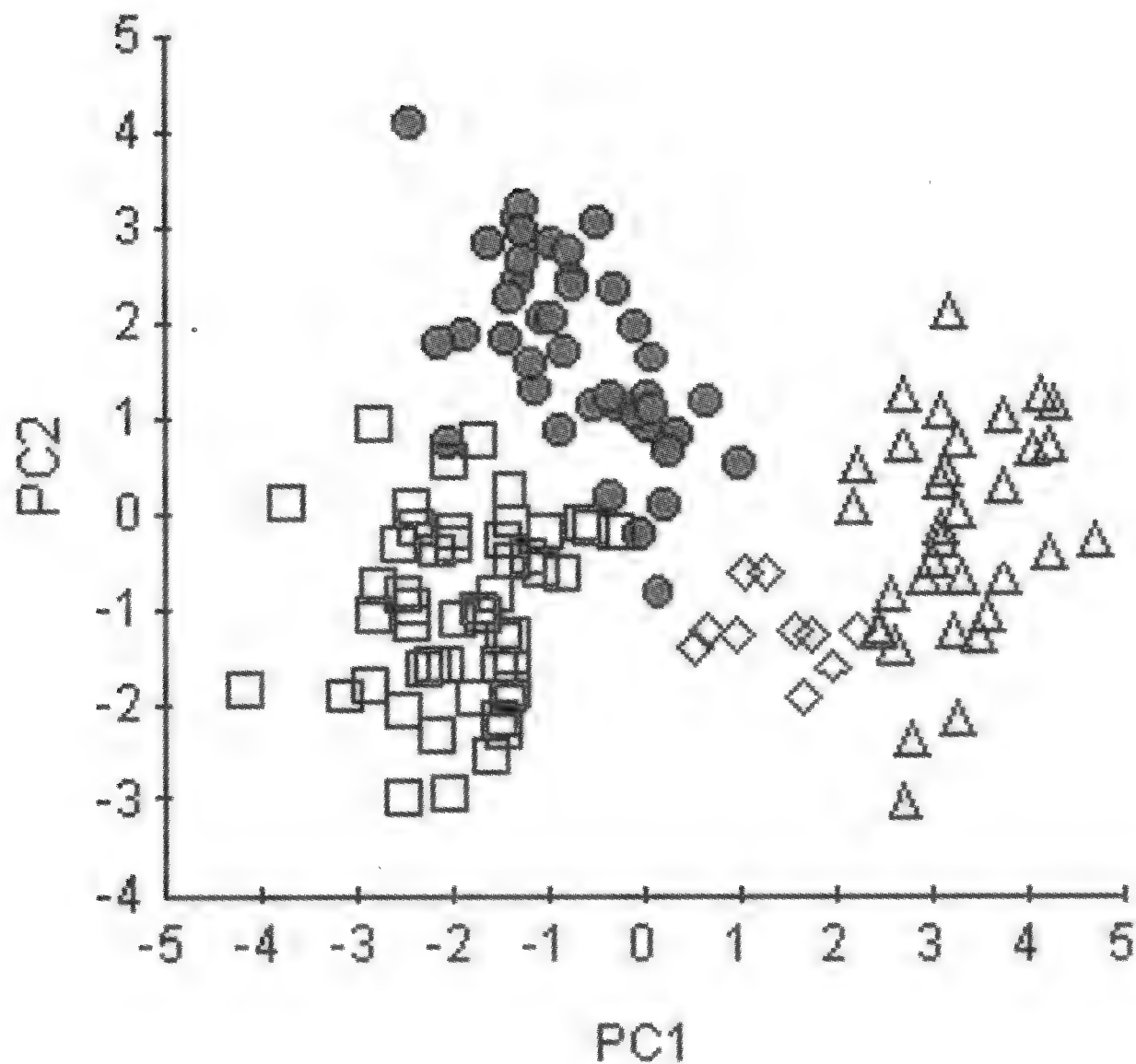
## MULTIVARIATE RESULTS

### CLUSTER ANALYSIS

The dendrogram (fig.1) showed a hierarchical arrangement among all 136 *Benthonellania* specimens. Two main branches were linked at about 103 linkage distance. Each one branched again into two, forming a four-branched tree. Each branch corresponded to a nominal taxon as identified by the capital letters at the bottom, the number denoting the individual identification of the specimen. *Benthonellania xanthias* (represented by letter B) is close to *Benthonellania* sp. C; while in the other tree branch, *Benthonellania* sp. A and *Benthonellania* cf. sp. A (represented by the letter I) are related. Note that the dissimilarity between *Benthonellania* sp. A and *Benthonellania* cf. sp. A is less (they have a higher conchological affinity) than the dissimilarity between *B. xanthias* and *Benthonellania* sp. C. Only 6 of 136 specimens were misclassified, e.g., specimens B12 and B14 together in species-group I; specimens B4, B11 and B18 together in species-group C; and specimen C5 together with *B. xanthias*.

### PCA

The figure 2 shows a non-hierarchical representation of the same data set. PC1 completely distinguished *Benthonellania* sp. A, since all the specimens assigned to this taxon showed values equal to or higher than 2 along this axis. *Benthonellania* cf. sp. A (represented by letter I) was characterized by values between 0 and 1.7, which were



**Fig. 2** Diagrammatic representation of the 136 specimens according PC 1 and PC 2. Triangles = *B. coronata* n.sp.; diamonds = *B. cf. coronata*; circles = *B. xanthias* and squares = *B. multicostata* n.sp.

partially overlapped by the scores of *B. xanthias*. The PC2 axis effectively separated *B. xanthias* from *Benthonellania* sp. C: all except two specimens of the former taxon showed positive scores, whereas most specimens of the latter showed negative scores along this axis.

PC1 explained about 43.7 % of total conchological variability, while PC2 explained about 21.0 %. Together these axes represented 64.7 % of total conchological variability. Table 1 shows the eigenvalues (the contribution) of each variable on PC1 and PC2. We can interpret the PC1 axis as the influence of NCB, NAR1, NAR2, NAR3, AA and AL, i.e., a mix of contributions of different kinds of sculpturing such as lines in the base, axial ribs, and nodules at the adapical end of the axial ribs. PC2 is mainly explained by TWEx1-2, SA, PH and BW, a mix of shell-form characters such as shell angle and rate of whorl expansion.

## SYSTEMATIC RESULTS

Family Rissoidae Gray, 1847

Genus *Alvania* Risso, 1826

Type species *Alvania europaea* Risso, 1826, subsequent designation by Nevill, 1885.

*Alvania colombiana* Romer & Moore 1988  
131-133, figs1-2

Type locality off the west coast of Florida (USA). Holotype in USNM.

Material examined IBUFRJ 13935, 11°23'21"S, 37°04'30"W, 100 m depth, 16/iv/2002 [1].



TABLE 1  
Eigenvalues of most significant morphometric variables on the two main PC axis. See text for abbreviations.

Variables/ PC	PC1	PC2
AA	-0.374	-0.127
AL	0.345	-0.123
NCB	-0.358	0.204
NAR1	-0.325	0.112
NAR2	-0.381	-0.092
NAR3	-0.355	0.161
VNAR2-3	-0.003	-0.340
TWE <sub>x1-2</sub>	-0.065	-0.418
PH	-0.157	0.376
SA	-0.203	-0.413
BW	-0.189	0.342

Genus *Benthonellania* Lozouet, 1990.

Type species by original designation *Benthonellania gofasi* Lozouet, 1990.

*Benthonellania xanthias* (Watson, 1886)

*Rissoa xanthias* Watson, 1886 : 588-589, Pl.44, fig.4. Type locality off Culebra Island, West Indies and off Pernambuco (Brazil). Type in BMNH.

*Material examined* IBUFRJ 13932, 22°36'12" S, 40°03'55"W, AG coll., 21/09/2000 [4]; IBUFRJ 13933, 22°41'8"S, 40°26'54" W, AG coll., 17/09/2000 [5]; --PCABS: DOUFPE 4452, stn 5.3 [1]; DOUFPE 4457, stn5.3 [1]; --MD55: MNHN, stn DC70 [1]; MNHN, stn DC72 [2]; --REVIZEE: IBUFRJ 13916, stn 25 A [1]; IBUFRJ 13917, stn 25 A [1]; IBUFRJ 13915, stn 41F [1]; IBUFRJ 13914, stn 41F [5]; --CBDSEP: IBUFRJ 13913, stn 60 [1]; IBUFRJ 13918, stn 57 [1]; IBUFRJ 13919, stn 4, [2]; IBUFRJ 13924, stn 45 [4]; IBUFRJ 13922, stn 80 [3]; IBUFRJ 13921, stn 84 [6]; IBUFRJ 13920, stn 85 [1]; IBUFRJ 13925, stn 77 [2].

*Benthonellania donmoorei* Moolenbeek & Faber, 1991

*Benthonellania donmoorei* Moolenbeek & Faber, 1991 : 51-53, figs1-3.

*Type locality* off Barbados. Holotype in ZMA.

*Material examined* PCABS: DOUFPE 4460, stn 12.1 [1]; DOUFPE 4461, stn 2.2 [2]; DOUFPE 4462, stn 2.1 [1]; DOUFPE 4463, stn 2.1 [1]; DOUFPE 4464, stn 2.1 [1]; DOUFPE 4674, stn 2.1 [1]; DOUFPE 4505, stn 1.3 [2]; DOUFPE 4501, stn 9.2 [1].

*Benthonellania multicostata*, new species figs 5-6

*Description* Shell conical, moderately solid, adults about 1.05 mm long. Protoconch with 3.5-4.25 whorls, with two nodulous spiral keels on the lower half, first protoconch whorl covered by many irregular oblique lines, changing ornamentation pattern to 4-5 spiral cordlets and finally showing two spiral keels. From the upper keel arise about 38 irregular riblets toward the bottom keel, not touching it or blending with the very weak riblets that issue from it. The same occurs between the bottom keel and the suture. There is a short set of 38 irregular riblets from the suture toward the bottom. The protoconch profile is pagoda-shaped.

Teleoconch with about 3 whorls, spire whorls rather convex with no discernible



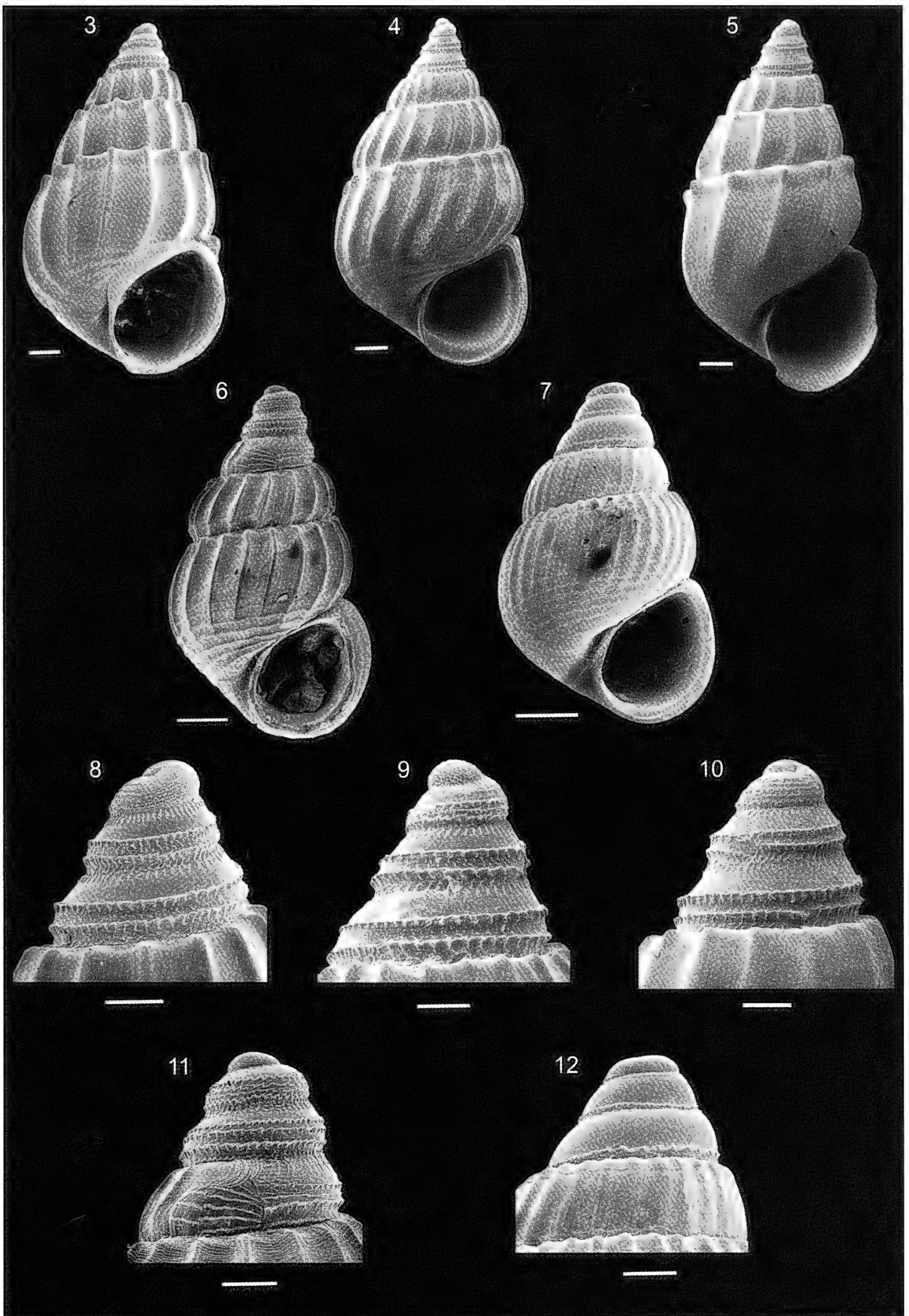


Fig. 3–12 *Benthonellania* spp. and *Alvania colombiana*. Figs. 3,8 *B. xanthias* (IBUFRJ 13916); 4,9 *B. multicostata* n.sp. (Holotype IBUFRJ 13906); 5, 10 *B. coronata* n.sp. (Holotype IBUFRJ 13908); 6–11 *B. donmoorei* (DOUFPE 4462); 7, 12 *A. colombiana* (IBUFRJ 13935). Figs. 3–7 whole shell, scale bar = 200  $\mu$ m; figs. 8–12 protoconchs, scale bar = 100  $\mu$ m.



subsutural rim and 17 curved axial ribs (ca. 18 ribs on first teleoconch whorl, 19 ribs on penultimate whorl). Body whorl bulged with axial ribs fading towards umbilical area. Spiral sculpture limited to the base, about 3-4 spiral rounded cords. Aperture ovoid, slightly opisthoclinal, outer lip thickened. Inner lip thin. A small chink-like umbilicus present.

Operculum, radula and soft parts unknown.

*Derivation of name* From Latin *multi* = many; *costae* = ribs, riblets, referring to the many axial ribs present in this *taxon*.

*Type material* Holotype IBUFRJ 13906, REVIZEE stn 504; paratypes 1- MNHN MD55 stn DC75 [6], Rv.MD col. [6]; paratypes 2- MORG 41069 [2]; paratypes 3 – MZSP 38410 [2]; paratypes 4- ASNP [2]; paratypes 5 – IBUFRJ [23]; paratypes 6 MNRJ 9959 [2]; paratypes DOUFPE 4459 [2]. All paratypes except from MNHN are from type locality.

*Additional material* REVIZEE: IBUFRJ 13903, stn C13; IBUFRJ 13904, stn 1F; --PCABS: DOUFPE 4455, stn 3.3; DOUFPE 4453, stn 9.2.

## DISCUSSION

*Benthonellania multicostata* n.sp. and *B. xanthias* show similar spire angles but very distinctive whorl profiles. While *B. multicostata* has strongly convex whorls, *B. xanthias* has almost flat whorls. *B. xanthias* shows a typical subsutural ring with small nodules at the adapical end of the axial ribs, whereas *B. multicostata* never shows adapical nodules or a subsutural ring. *B. multicostata* has about 22 axial ribs on the body whorl, while *B. xanthias* has about 14. Finally, the protoconch of *B. multicostata* is longer than that of *B. xanthias*.

*Benthonellania acuticostata* (Dall, 1889) (Lozouet, 1990: figs 16-17) is taller and has more whorls in adult specimens than *B. multicostata*. The axial ribs are orthoclinally oriented in *B. acuticostata* but opisthoclinal in *B. multicostata*. Moreover, the protoconchs differ in both profile and ornamentation.

*Benthonellania donmoorei* shares with *B. multicostata* the general convex profile, opisthoclinal axial ribs and spiral cords at the base. Both species have thickened outer lips, but the lip of *B. multicostata* is less thickened. Additionally, *B. multicostata* can be distinguished from *B. donmoorei* by its more elongate and pagoda-like protoconch form; its more numerous axial ribs (22 axial ribs on the body whorl against 16 in *B. donmoorei*) and its larger spire angle. Finally, *B. donmoorei* shows fine spiral threads over the entire teleoconch, which are absent in *B. multicostata*.

*Benthonellania multicostata* can be easily separated from *B. coronata* (compare the following description of the latter new taxon) by its large spire angle, higher number of axial ribs, absence of nodules at the adapical end of the axial ribs, thickened aperture and the presence of spiral cords at the base.

### *Benthonellania coronata*, new species figs 7-8

*Description* Shell conical, slightly more oblong than usual for the genus, thin, adults about 1.02 mm long. Protoconch with 3.0-3.5 whorls, with two nodulous spiral keels on the lower half, first protoconch whorl covered by 3-4 cordlets covered with irregular low nodules along them; these nodules tending to organize themselves in additional cordlets, posteriorly changing the ornamentation pattern to 3-4 spiral zigzag cordlets



and finally showing two spiral keels. From the upper and lower keels arise about 44 irregular riblets that tend to blend in the middle of both keels. The same occurs between the bottom keel and the suture. There is a short set of 44 irregular riblets extending from the suture toward the bottom. The protoconch profile resembles a pagoda.

Teleoconch with about 3 whorls, spire whorls rather flat with about 10 axial ribs on body whorl, from the adapical portion of axial ribs rising as more or less acute nodules. The axial ribs have an interaxial space of twice or more the width of the ribs. There are about 12 ribs on the penultimate whorl and 13 ribs on the first whorl. Axial ribs fading away on the periphery of the body whorl, barely invading the base. Usually no spiral ornamentation. Aperture orthocline, outer and inner lips thin. A small chink-like umbilicus present but barely visible.

Operculum, radula and soft parts unknown.

*Derivation of name* From Latin *corona* = crown, referring to the ring of nodules encircling each whorl.

*Type material* Holotype IBUFRJ 13908, REVIZEE stn A3; paratypes MORG 41068 and MZUSP 38411. From type locality; paratypes MNHN, MD55 stn CB104; paratypes MNRJ 9960 REVIZEE stn 52C; paratypes ANSP and DOUFPE 4460 from REVIZEE stn C13.

*Additional material* MD55: MNHN, stn CB76 [2]; --REVIZEE: IBUFRJ 13909, stn 52C [1]; IBUFRJ 13907, stn 52C [5]; IBUFRJ 13910, stn C13 [9]; IBUFRJ 13934, stn A3 [3]; IBUFRJ 13911, stn 25 A [11]; IBUFRJ 13912, stn 1F [1].

## DISCUSSION

*B. coronata* has a nearly subcylindrical shell profile, strong adapical nodules, orthocline aperture and no trace of spiral ornamentation. This unusual combination of shell characters distinguishes it from most other known congeners, except a group of 10 shells from northeast Brazil. The results of multivariate analysis (figs 1 and 2) confirmed that both *taxa* are devoid of spiral sculpture, have a reduced number of adapically nodulous axial ribs and essentially the same protoconch. This northeastern group of shells is significantly shorter than *B. coronata* and its spire angle is larger. Our multivariate analysis showed that it is closer to *B. coronata* than any other, but dissimilar enough to keep its own identity. Considering that the number of specimens is too small to adequately establish the intrapopulation shell variability and the allopatric geographical distribution of these populations, we provisionally considered this group of ten shells as a variety of *B. coronata*.

At first glance, *B. coronata* is similar to the African *B. gofasi* Lozouet, 1990 (Lozouet, 1990: figs 20-23), because both show broad interspaces between the axial ribs, relatively few axial ribs and strong, adapically positioned nodules on these ribs. However, *B. gofasi* has clear spiral cords on the base while *B. coronata* lacks such cords. In *B. gofasi*, the protoconch has a regularly convex profile and the surface is covered with scale-like ornamentation (Gofas, 1999, fig. 68); whereas in *B. coronata* the profile of the protoconch is pagoda-like and there are two nodulous spiral keels on the protoconch. Clearly the similarity between these *taxa* is only superficial.

*Benthonellania donmoorei* Moolenbeek & Faber, 1991 - figs 9-10

The Brazilian specimens assigned to *B. donmoorei* are completely congruent with the

illustration of *B. donmoorei* by Moolenbeek & Faber (1991, 52: 1-3), particularly in respect to the proto- and teleoconch profile and sculpturing (fig.9). This is the first record of *B. donmoorei* in Brazilian waters, and extends the known geographical distribution from the Caribbean to South America.

## GENERAL DISCUSSION

Moolenbeek & Faber (1991) suggested that *Alvania colombiana* Romer & Moore (1988) should be transferred to *Benthonellania*, but did not discuss their reasons. We present the first SEM photomicrograph of *A. colombiana* (figs11-12). In our view, the only characters offering a reason to agree with Moolenbeek & Faber (1991) are the general globose profile and the presence of numerous axial ribs as the dominant sculpture. Many other *taxa* (perhaps genera), both within and outside of the Rissooidea, fit this character-set (cf. Bouchet & Warén, 1993). Although the protoconch definition of *Benthonellania* was left "open" by Lozouet (1990), the protoconch sculpture pattern (at least in the Recent species) is consistent and can be distinguished from the pattern in *Alvania*. *A. colombiana* clearly fits in the *Alvania* pattern of form and sculpture (cf. Ponder, 1984; Bouchet & Warén, 1993) and must be maintained at genus *Alvania*.

Romer & Moore (1988) considered *B. acuticostata* as a synonym of *B. xanthias*, but Lozouet (1990) reestablished *B. acuticostata* as a distinct species. Although we have no access to a sample of *B. acuticostata*, its forms and dimensions (Lozouet, 1990: figs 16-17) strongly induced us to agree with Lozouet.

In respect to similarities and dissimilarities among the protoconchs of *Benthonellania* species, all the fossil taxa (*B. antepelagica* Lozouet, 1990; *B. praexanthias* Lozouet, 1990; *B. oligostigma*, *B. agastachys* and *B. fayalensis*, but *B. praexanthias*) have a paucispiral protoconch with little or no sculpturing. On the other hand, all the recent species *B. xanthias*, *B. acuticostata* (Dall, 1889), *B. gofasi*, *B. gofasi sensu* Bouchet & Warén, 1993 (see below), *B. multicostata*, *B. coronata* and *B. donmoorei* have strongly sculptured multispiral protoconchs with different profiles. *B. xanthias*, *B. multicostata*, *B. coronata*, *B. donmoorei* and the fossil *B. praexanthias* share the pagoda-like protoconch form; *B. gofasi*, *B. gofasi sensu* Bouchet & Warén and *B. acuticostata* show evenly convex protoconch whorls. Whether these differences among recent species represent taxonomic (phylogenetic) affinities remains a question for future investigation, especially when information about the soft parts becomes available.

Bouchet & Warén (1993: figs 1583 and 1589-1590) illustrated a specimen from MONACO Exp. St 1116 (31°44'N, 10°47'W, 2165 m) which they assigned to *B. gofasi*. However, their specimen differs in several respects from the type specimen shown by Gofas (1999: 96, fig. 65) and from additional specimens, especially the protoconch in Gofas' figure 68. The species illustrated by Bouchet & Warén has more axial ribs and cords at the base, and its axial ribs do not show the rounded nodules on the adapical ends of axial ribs that are typical of *B. gofasi*. Moreover, the shell described by Bouchet & Warén has a "very distinct zigzag sculpture of protoconch" (their figure 1589-1590), while *B. gofasi* has a protoconch sculpture pattern that resembles a linear arrangement of scales (Gofas, 1999: fig. 68). Clearly Bouchet and Warén's specimen represents a still-undescribed species.

Although morphometrics is not a new taxonomic tool, this method has been used more commonly in the last decade (cf. Shimek, 1989; Kilgour, Lynn & Mackie, 1990; Ward, Goater & Mikos, 1997; Tursch, Greifeneder & Huart, 1998; Tanaka & Magalhães, 1999). The joint use of ordination and classification techniques is especially recommended; while the former emphasises continuity of the data, the latter searches



the discontinuity of them. In our examination (figs 1 and 2), the final results of both approaches were in agreement. In regard to the set of shell characters, we could easily distinguish three main specimen groups (one of them, *B. xanthias*, already named). When we examined the dissimilarities among the 4 formal *taxa* treated herein, the close morphological relationship between *B. cf. coronata* and *B. coronata* became obvious (fig. 1). However, although PCA (fig. 2) was able to discriminate between them, we decided to await collection of more specimens to form a firmer basis to recognize *B. cf. coronata* as a distinct *taxon*, since some degree of geographical variation may be a factor. Our multivariate morphometric approach was able to classify satisfactorily 130 of 136 cases, and even most of those individuals which were not previously assigned to species could be identified.

### ACKNOWLEDGEMENTS

Our thanks to several colleagues for their cordial assistance: Dr. Pierre Lozouet pointed out the differences between *B. gofasi* and our *B. coronata*; Dr. Philippe Bouchet for the loan of the MD55 material cruise; Dra. Deusinete de Oliveira Tenório for the loan of *Benthonellania cf. coronata* and *B. donmoorei*; Dr. Juan Manoel Díaz confirmed the identification of *A. colombiana*; Drs. André Esteves and Carlos Henrique Caetano helped in the statistical analysis. And to Petrobras (Brazilian Petroleum Co.) for the possibility to get part of these material. This research was partially supported by CNPq from Brazil.

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# ARION OCCULTUS N. SP., A NEW SLUG OF SUBGENUS KOBELTIA SEIBERT (PULMONATA: ARIONIDAE) FROM IRELAND

ROY ANDERSON<sup>1</sup>

*Abstract* A new species of slug, *Arion occultus*, is described from Co Down in Northern Ireland. It belongs to the *hortensis* group in subgenus *Kobeltia* of *Arion*, and is superficially similar to *Arion distinctus* Mabille. Its origins are unknown and it appears to be a recent immigrant to Ireland. Distinctive features include: a rough external appearance due to strongly raised and keeled tubercles on the dorsum; a uniformly yellow and rather broad foot fringe; an epiphallus which lacks either pigmentation or a bulbous swelling at its apex and which also lacks an epiphallus process at the junction of the epiphallus with the distal oviduct, features which are otherwise general in the *hortensis* group; the possession of a simple spermatophore comprising an oblong, flattened sac lacking serrations or other distinctive features. Externally the integument possesses abundant yellow chromatophores lightening an otherwise predominantly dark dorsum. Size is larger than *distinctus* with broad, high lateral bands, below which the sides are predominantly pale or white, rather than grey. Although superficially similar to the central European *Arion alpinus* the latter does not belong to the *hortensis* group and has a very different genital anatomy.

*Key words* *Arion*, *occultus*, *Kobeltia*, *Arionidae*, *Mollusca: Pulmonata*, new species, Ireland.

## INTRODUCTION

The terrestrial pulmonate family Arionidae is represented in Britain and Ireland by thirteen species (Davies 1979, 1987; Quick 1960). Work in progress (pers. comm. of S. M. Davies) is continuing to clarify the status and distinctive features of some of these. Subgenus *Kobeltia* Seibert is represented by four species, *Arion intermedius* Normand, *A. hortensis* Férussac., *A. distinctus* Mabille and *A. owenii* Davies (Davies 1977, 1979).

*Kobeltia* has approximately twelve described species in Europe. The species tend to be small, retiring and cryptic in colouration and some authors have suggested that a number of additional species may remain to be described (Falkner *et al.* 2002). The species which is described below may prove difficult to separate in the field from its congeners in the *hortensis* group, notably from *A. distinctus* and *A. hortensis*. The conditions of its discovery suggest a recent introduction to Ireland from a country or countries unknown, but likely to be within western or south-western Europe.

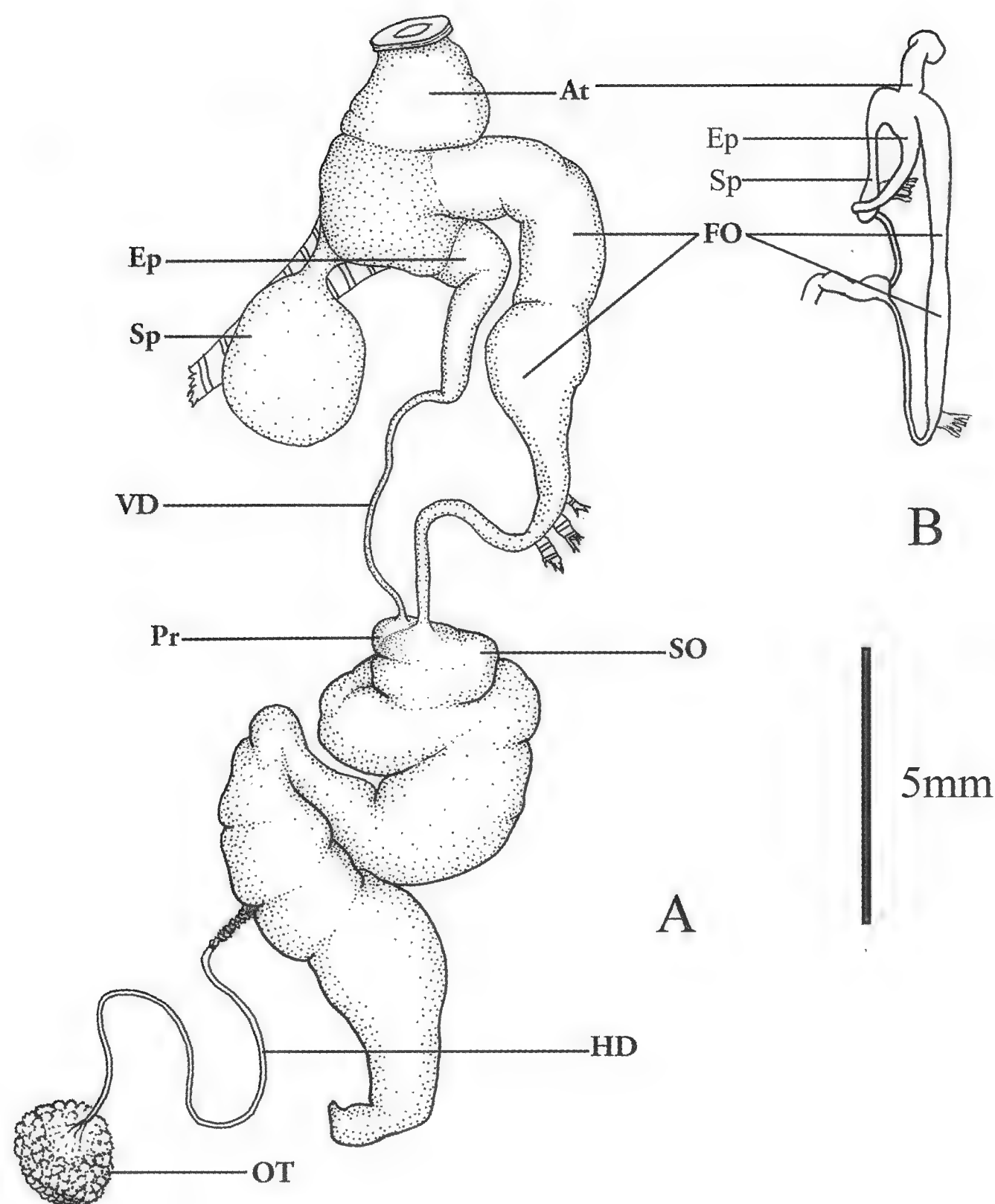
## MATERIALS AND METHODS

Study material was collected near Ballywalter, Co Down.

*Type locality* Bank Lodge Woods, Ballywalter Estate, Ballywalter (Irish grid J631676), Co Down, N. Ireland (R. Anderson: 24/v/1986 up to 28/iv/2003).

The site is on the seaward margin of a large private estate and associated farm. The ground is sandy and planted with *Acer pseudoplatanus* L. There is little or no shrub layer and a sparse herb layer comprising mainly abundant *Hyacinthoides non-scripta* (L.) Chouard ex Rothm. Margins of the site are very disturbed and one section of the

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**Figure 1** A. Genital tract of a mature specimen (paratype) of *Arion occultus*: At atrium; Ep epiphallus; FO free oviduct; Gl glandular tissue of the distal free oviduct; HD hermaphrodite duct; OT ovotestis; Pr prostate gland ; SO spermoviduct; Sp spermatheca; VD vas deferens. B. Distal genitalia of an immature specimen, locus typicus, April 2004.

woods has been used for infill with rubbish from the estate. The following molluscs have been recorded: *Cochlicopa lubrica* (Müller); *Cochlicopa lubricella* (Porro); *Columella edentula* (Draparnaud); *Leiostryla anglica* (Wood); *Lauria cylindracea* (da Costa); *Vallonia costata* (Müller); *Discus rotundatus* (Müller); *Arion ater* (L.); *A. subfuscus* (Draparnaud); *A. silvaticus* Lohmander; *A. distinctus* Mabilie; *A. hortensis* Férussac; *Vitrina pellucida* (Müller); *Vitrea contracta* (Westerlund); *V. crystallina* (Müller); *Nesovitrea hammonis* (Ström); *Aegopinella nitidula* (Draparnaud); *A. pura* (Alder); *Oxychilus cellarius* (Müller); *O. alliarius* (Miller); *Tandonia budapestensis* (Hazay); *Limax maculatus* (Kaleniczenko); *L. maximus* L.; *Lehmannia marginata* (Müller); *L. valentiana* (Férussac); *Deroceras panormitanum* (Lessona & Pollonera); *D. reticulatum* (Müller); *Euconulus fulvus* (Müller); *Clausilia bidentata* (Ström); *Cochlicella cuta* (Müller); *Trichia hispida* (L.); *T. striolata* (C. Pfeiffer); *Cepaea nemoralis* (L.); *Cryptomphalus aspersus* (Müller).

*Other sites* apart from Bank Lodge, it has only been observed in the contiguous Ballywalter Estate (Irish grid J626677) separated from Bank Lodge by a broad field and a small road. The Estate is isolated from other parcels of mature woodland in this part of Co Down by at least 7 km and there is no record of the species from neighbouring estates or other wooded sites.



## RESULTS

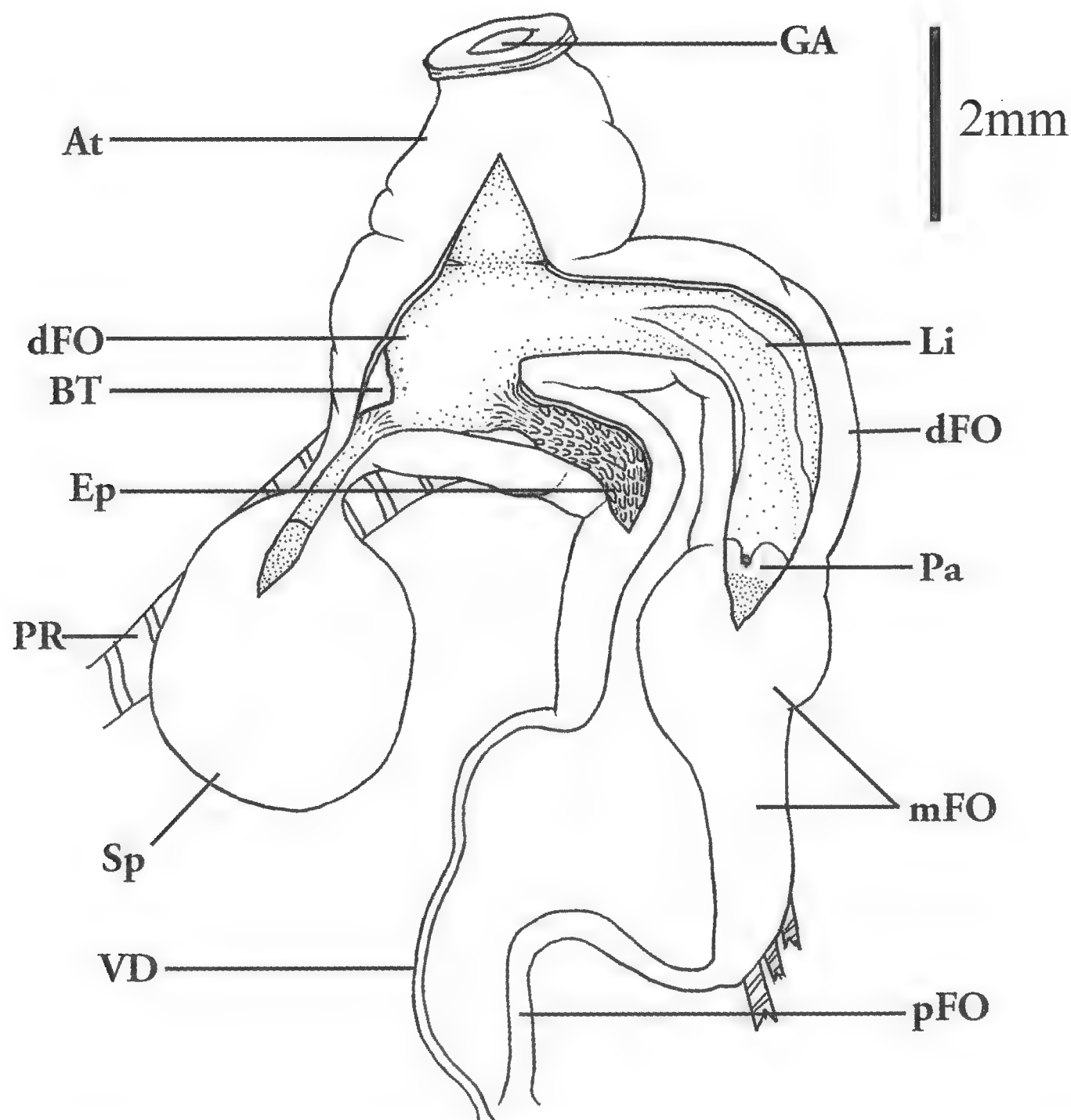
DESCRIPTION OF *ARION OCCULTUS*

*Derivation of name* *occultus*, obscure, hidden (Latin).

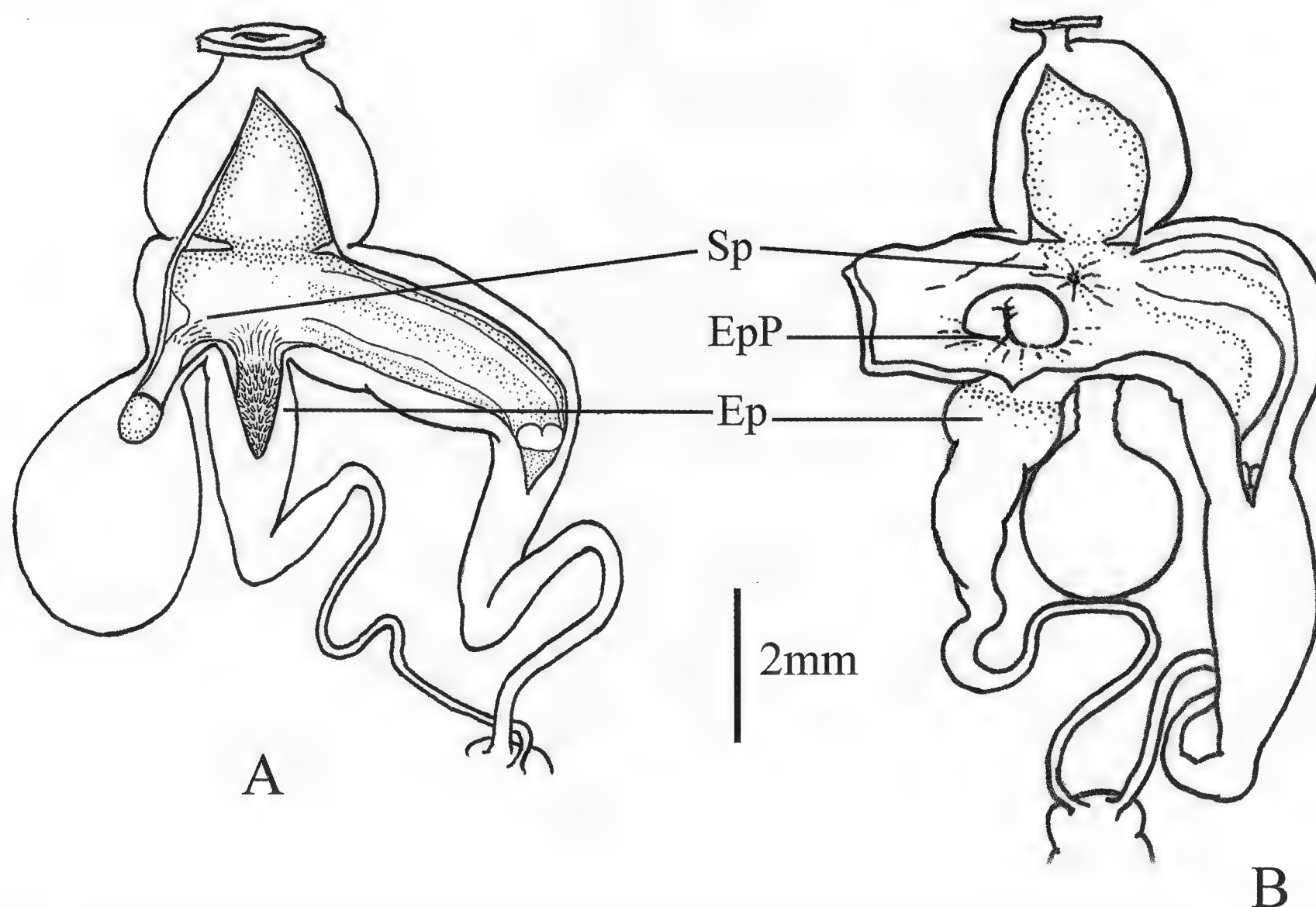
*Type series* The holotype plus twelve paratypes were deposited in the collection of the National Museum of Wales, Cardiff (accession numbers (holotype) NMW.Z.2003.092.00001, (paratypes) NMW.Z.2003.092.00002). Nine paratypes were deposited in the Natural History Museum, London (accession number 20030569), and nine in the National Museum of Ireland (accession number NMI 75:2003).

*Material studied* In addition to the type series listed above, approximately 80 specimens at all stages of development were examined in this study. Twenty mature specimens were dissected to display the features of the internal (principally male genital) anatomy. The first copulations were observed in 1992 (three in all) and one such copulation is illustrated in Plates 4 and 5. Since 1992 copulations have been observed almost annually. In preparation for the description presented here, eight copulations were closely observed in 2002-2003. The description of internal parts which follows is based on alcohol material from earlier years plus freshly collected material in 2002-2003.

*Shell* Absent or present only as a few fine granules in a fluid-filled sac within the mantle tissue.



**Figure 2** Distal genitalia of the holotype of *Arion occultus* laid open to show internal anatomy: **At** atrium; **BT** bracing tissue; **dFO** distal free oviduct; **Ep** epiphallus; **GA** genital aperture; **Li** ligula; **mFO** median free oviduct; **Pa** papilla at the outlet of the median free oviduct; **pFO** proximal free oviduct; **PR** penial retractor muscle; **Sp** spermatheca; **VD** vas deferens.



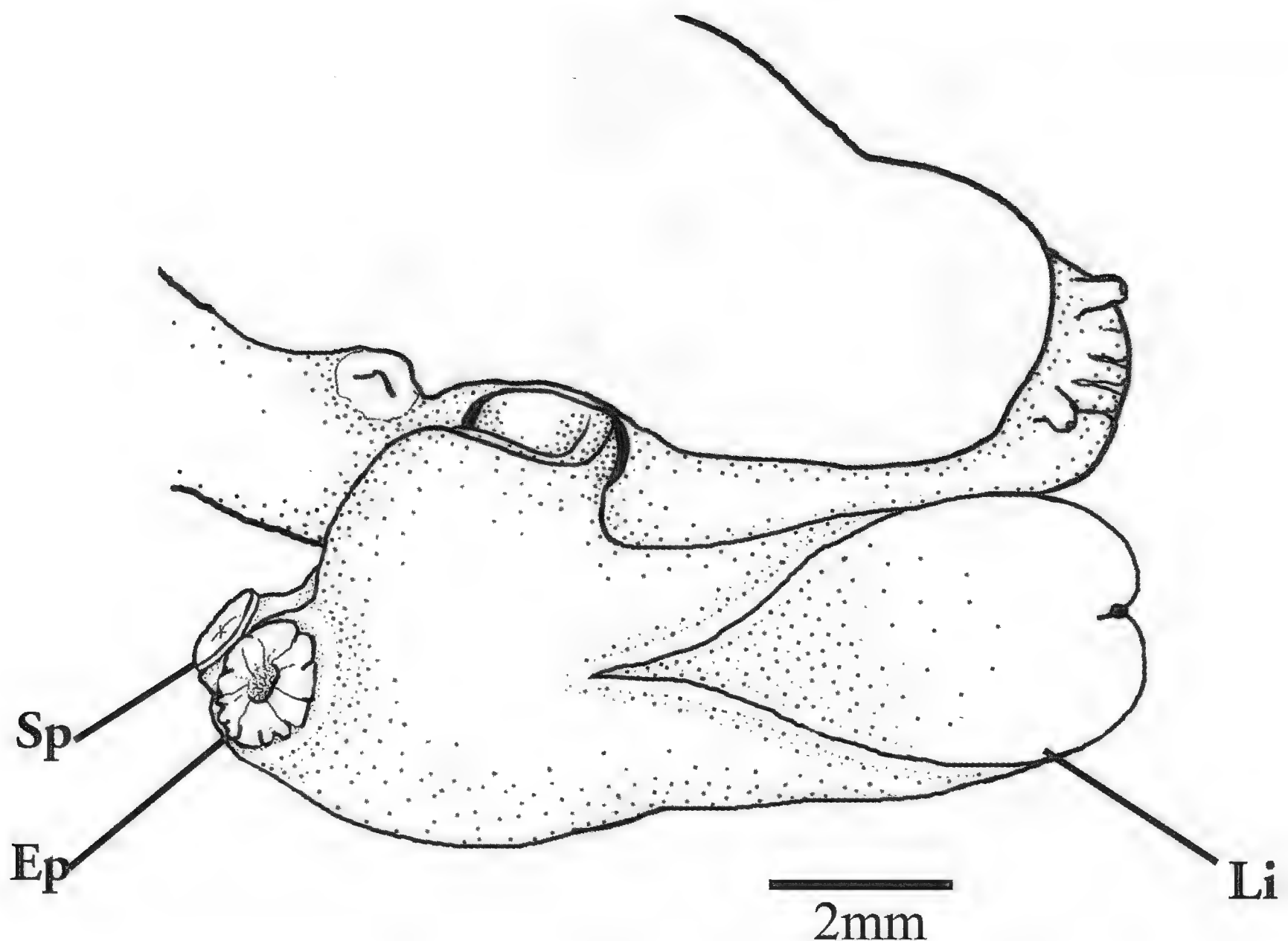
**Figure 3** Distal genitalia of a paratype of *Arion occultus* (A), compared to that of a specimen of *A. distinctus* (B), both from the locus typicus at Ballywalter: Ep epiphallus; EpP epiphallus process; Sp spermathecal canal.

*External appearance* A medium-sized slug (30-42mm crawling; 19-28mm at rest), appearing depressed and rather parallel-sided in soil or under stones. In cool, humid conditions above ground it forms a distinctive bell shape (Plate 1) by a degree of proximo-distal contraction otherwise observed by the author only in *Arion intermedius* within British Isles *Kobeltia*.

The dorsal tubercles are strongly raised, an irregular oblong in shape, and keeled or ridged. These are arranged in irregular lines on the back and sides (Plate 1), and are emphasised by being slightly paler (due to the presence of chromatophores) than the dark inter-tubercular pits. The dorsum has an underlying dark brown colouration, sometimes with a faint purplish tinge which is difficult to see in life but becomes more apparent in alcohol. In life the colouration is most often a distinctive yellowish-grey from a large concentration of yellow chromatophores on the upper surface. Lateral bands are well developed, coloured mid to dark grey but appearing black in alcohol, broad and high on the sides (Plate 3). Sides below the lateral bands are lighter than the dorsum, mainly white to yellowish (Plate 2), occasionally pale grey. Sides above the bands are uniformly dark, gray to brown to black and lacking the paler 'shadow' bands apparent in alcohol material of *Arion distinctus* or *A. hortensis*.

The sole is pale yellow but may be orange in some specimens, varying with diet and the clearly dependent upon the density of yellow/orange mucus secreted by the animal. A characteristic feature of this species is that rough handling rapidly removes the sole mucus leaving the sole a plain whitish shade. The orange mucus is very slow to regenerate (days/weeks). The centre of the foot is translucent and the dark contents of the gut show through along the middle. The foot fringe is broad and uniformly orange or yellow, lacking any darker pigmentation, including the spots or stripes seen at the tail in related species of *Kobeltia* (see tail in Plate 4). The tentacles are dark and blue-grey to blue-black in colour (Plate 2).





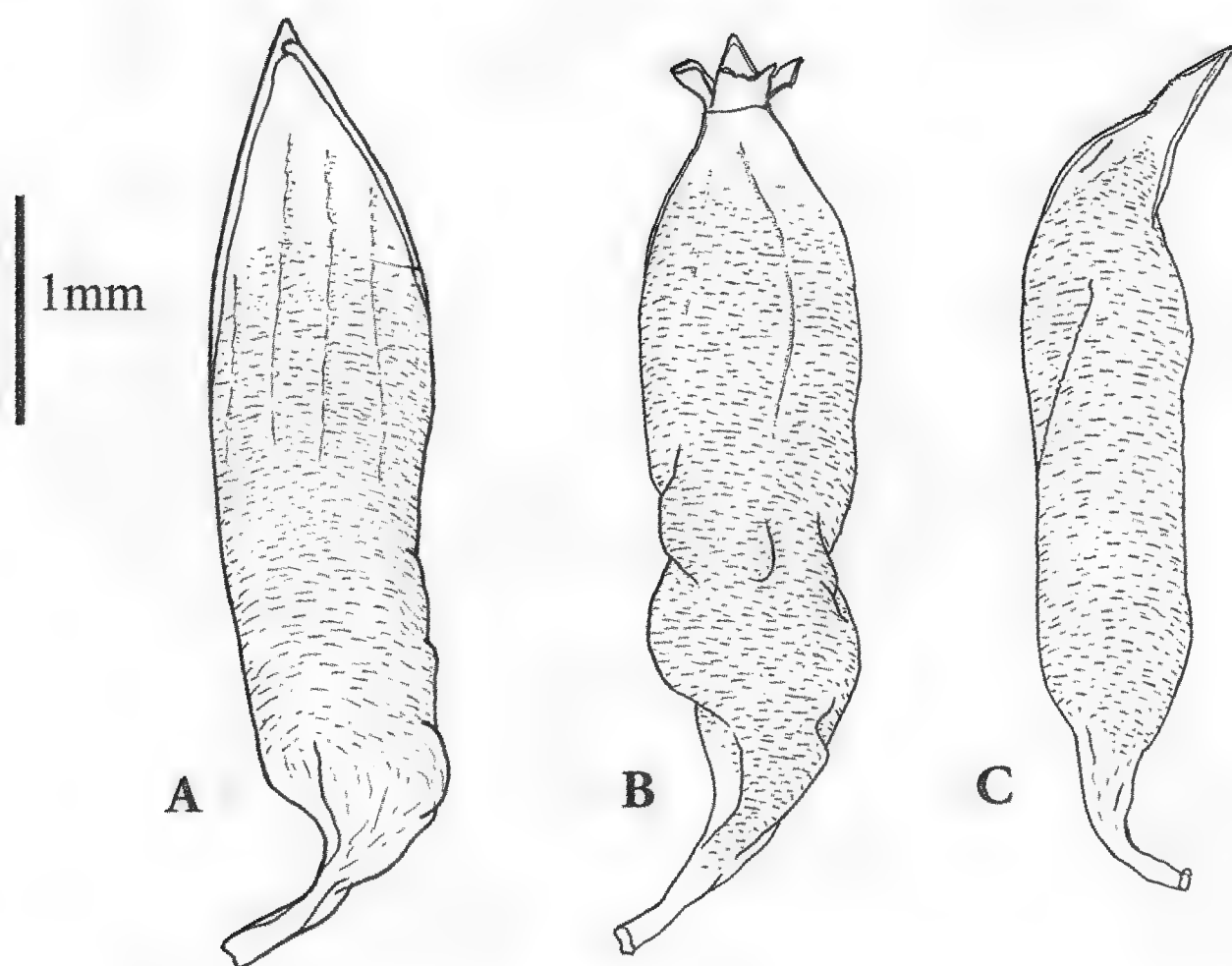
**Figure 4** Extruded distal genitalia in an alcohol specimen of *Arion occultus* killed during coitus by rapid freezing. To show: **Li** ligula, comprising the everted distal free oviduct; **Ep** the outlet of the epiphallus in the wall of the distal free oviduct; **Sp** the outlet of the spermatheca in the wall of the distal free oviduct.

*Radula and jaw* The jaw is of similar construction to those of other species in the *Arion hortensis* group (Quick 1960) i.e. odontognathous, and with 15 broad ribs. The radula is similar to that of other small *Arion* (Quick 1960) at  $11 \times 2.5$  mm and has a radular formula of C.11.27  $\times$  100.

*Genital tract* Fifteen adult animals were dissected and the genital anatomy compared. These were collected between 1986 and 2003, either in the spring or in the autumn breeding periods.

The distal (lower) atrium in sexually mature animals appears white and non-specialised (Figure 1) whereas it appears distinctly glandular in *A. distinctus*. As in other species of the *hortensis* group the atrium is separated by a constriction from the space into which the spermatheca and epiphallus open. This latter area is usually referred to as the upper atrium (Quick 1960) but is functionally part of the distal oviduct and is referred to hereafter as distal free oviduct (dFO in Figure 2). The walls of the distal oviduct in the vicinity of the spermathecal canal and epiphallus are inflated by yellowish glandular tissue. This is particularly evident after coitus. As already noted, glandular tissue is not apparent in the walls of the (lower) atrium, although Quick (1960) describes the walls of the atrium in *Arion hortensis* agg. as being glandular. This is certainly the case with *A. distinctus*.

As in related species, the spermathecal canal is short and robust and leads to a large, ovoid spermatheca (Figure 2). Unlike other *hortensis* agg. the spermatheca sits well to the left of the epiphallus even when viewed from above, although in some specimens there is a degree of torsion and the genitalia must be turned over to the ventral view to see this (Fig. 2). In other species, it is the epiphallus which sits to the left with the spermatheca a more central position but behind the spermatheca and oviduct, in a tripod-like arrangement, as shown in Figure 3 (see also Quick (1960) Fig. 4A). A large whitish



**Figure 5** Spermatophores extracted from specimens of *Arion occultus* killed by rapid freezing during coitus: **A** typical specimen; **B** specimen with remains of bracing tissue adhering to the apex; **C** specimen with offset apex, other side.

thickening or shelf is present in the distal oviduct above the outlet of the spermathecal canal the purpose of which is unknown but it may serve to brace the spermatophore during coitus. There is no suggestion that this tissue is related to the epiphallus process which is located directly over the outlet of the epiphallus in related species.

The epiphallus is relatively small and conspicuously lacks the bulbous thickening and pigmentation at the apex seen related *Kobeltia* (as in Figure 3). Internally the epiphallus has the usual papilliform wall and is attached to a long, narrow vas deferens. No epiphallus 'process' (Backeljau & Van Beeck 1986), located where the epiphallus enters the lumen of the distal free oviduct (Fig. 3), has been observed in this species. Such a process has been observed in all other species of the *hortensis* agg. (e.g. *distinctus* in Figure 3), although it is vestigial in *intermedius*. It is regarded as a vestigial true penis (Backeljau & Van Beeck 1986). The lumen of the epiphallus in *occultus* therefore enters the distal free oviduct without obstruction.

The free oviduct is very long and robust distally, and is tripartite, as in *A. hortensis* and the tripartite form of *A. distinctus*. The length even in sexually immature animals (Figure 1B) is large compared to others of the *hortensis* group. This is further illustrated in the side-by-side comparison of *A. occultus* and *A. distinctus* in Figure 3. As in *distinctus* and *hortensis* the distal free oviduct has two raised folds running from the outlet of the median section towards the outlets of the epiphallus and spermatheca (Figure 2). These function as a ligula (Figure 4). The ligula when extruded forms a 'tongue' which acts as a stimulator during coitus (Plate 4).

The spermatophore of *A. occultus* is pliable when withdrawn from the spermathecal canal. It is of simple construction and comprises an oblong, somewhat depressed, chitinous sac which, apart from some stress lines on the surface, is featureless and somewhat variable in form (Figure 4 A, B, C). The tail is offset, coming to a blunt point. The tail may be seen protruding from the genital aperture immediately after coitus but the appearance of the spermatophore during coitus is inflated and cylindrical and what is visible of the tail is straight (Plate 5). Flattening of the spermatheca invariably occurs after extraction or on storage in alcohol. Indeed, the structure becomes so plastic after coitus and after entering the spermatheca that care is required on removal and on occasion it may be drawn out or stretched like melted plastic.



The extracted organ may have an irregular fringe at the apex (Figure 4, B) composed in part of bracing tissue torn from the entrance to the spermathecal canal. The overall impression, of an undifferentiated tube which may deform rapidly after coitus, contrasts with the more structured spermatophore of other *Kobeltia* such as *Arion hortensis* s.s., but particularly with the large sculptured spermatophores in species of subgenus *Arion* s.s. This at first sight appears to denote a primitive condition but there is a general tendency within the Arionidae towards the reduction and simplification of the copulatory organs (Backeljau & De Bruyn 1990). This has been called the “genital reduction hypothesis” and suggests that *A. occultus* is more, rather than less, evolved. Size of the spermatophore is  $4.1\text{mm} \pm 0.3\text{mm}$  (average of 5).

The proximal genitalia (Figure 1) are similar in construction to those of related species.

*Development* Breeding may occur throughout the year and varies from year to year between two main periods, a spring (May-June) period and an autumn (September-October) period. Juveniles and adults are present in mixed populations at most times of year. Coitus was observed (1992, 2002, 2003) a total of eleven times.

Coitus is preceded by a period of circling and mucus consumption, then eversion of the atria prior to contact and extrusion of the ligulae. Conjunction lasts 60-70 minutes (Plates 4, 5). When over, withdrawal of the points of contact leaves the short spermatophore tails protruding conspicuously from the atria (Plate 5).

The eggs are laid on the surface of soil and are similar to those of other *Kobeltia*, but are proportionately smaller. A batch of thirty was measured and had an average length of 2.3mm, and width of 1.9mm. For comparison, a batch of eggs of *Arion hortensis* from Bank Lodge Woods were  $3.03 \times 2.35\text{mm}$ . In shape the eggs form a slightly oblong sphere, and are coloured a pale yellow due to a slightly opaque mucus secretion. Occasionally the colour may be a brighter yellow from more strongly accreted mucus. Eggs are laid in batches of between 10 and 20 and clutch size varies from 30 to 50 (25 observations).

Hatching takes place within a month to six weeks depending upon temperature. The young are at first pale and translucent but rapidly darken over a few days to adopt the adult colouration.

*Seasonality* The species is largely subterranean, coming above ground in mild or wet weather but then disappearing entirely for long periods. It is able to flatten itself to an unusual degree under large rocks in the soil. It is rarely seen between October/November and the end of March. Mild weather in early April generally sees the first appearance of individuals after what may be assumed is a period of hibernation. In these respects behaviour is strikingly different from that of *A. hortensis* and *A. distinctus*, which remain active except in sub-zero temperatures.

In captivity the building of a hibernaculum within soil has been observed. This comprises an oblong chamber approximately 25mm x 15mm, shaped out of slime-wetted soil particles (Plate 6). Animals have been observed to remain inactive within this for periods of up to several weeks and upon forcible removal may take 5-10 minutes to become mobile again. Even when kept in small containers with some soil, animals tend to disappear at intervals and can only be relocated by the removal and sieving of soil.

*Bionomics* Like other *Kobeltia*, this species can be variable in its response to captive conditions, but in general adapts well. Green plants are eaten but a preference for crushed cereals has been noted and it appears to avoid fungi. In natural conditions it has been observed eating decaying plant material including glyphosate-treated weeds (on a lawn) and, near the sea at Ballywalter, decaying seaweed (*Fucus* sp.). In the

woodland habitat of its *locus typicus* there is little opportunity to consume green plant material except in spring and the diet probably comprises decaying leaf litter and plant roots for most of the year. It has not so far been observed in arable or root crops and is confined to well-shaded places so, despite its high fecundity at known sites, it has probably little potential to become a pest except in gardens.

#### SUMMARY OF CHARACTERISTICS.

The majority of features described above are common to other members of *Kobeltia*.

Distinctive external features are:

- 1) A 'rough' external appearance from conspicuous raised and keeled tubercles on the sides and back.
- 2) Strong suffused yellow colouration due to concentrations of yellow chromatophores on the back.
- 3) A comparatively pale sole from which mucus is readily removed by disturbance and which then remains pale for a long time (days/weeks)
- 4) A plain, unmarked, yellow foot fringe.
- 5) Broad lateral bands with the sides below these white or at least very pale.

Distinctive internal features include:

- 1) Lack of a swelling or pigmentation at the distal end of the epiphallus
- 2) Lack of an epiphallus structure
- 3) Possession of a simple, tubular spermatheca without serrations or other structures, forming a flattened sack.

#### COMPARISON WITH OTHER SPECIES.

In adults confusion is most likely to occur with adult *Arion distinctus*. In juveniles the bell profile and tuberculation may cause confusion with juvenile *A. intermedius*, or with juvenile *A. owenii*.

To illustrate the main differences with other *Kobeltia* a Table Key been constructed to British Isles *Kobeltia* (Table 1).

The most useful field characters are probably the distinctive yellowish shade of the upper surface combined with its 'roughness' and strong tuberculation. Similarly coloured *intermedius* (the hedgehog slug) are smaller and the tubercles are drawn into points, not keeled as in *occultus*.

In alcohol the diagnostic value of tuberculation and colour is lost and *occultus*, *hortensis* and *distinctus* become difficult to distinguish.. However, in *hortensis* and *occultus* the sides below the lateral bands are usually distinctively pale, nearly white, whereas in *distinctus* they are always grey and often as dark as the back. *Hortensis* and *occultus* may then be distinguished, as shown in Plate 3, by (i) the low bands of *hortensis* – high on the back in *occultus*, (ii) the paler 'shadow' band above the laterals in *hortensis* – absent or very faintly developed in *occultus*.

#### CONCLUSIONS

The new species of *Arion* subgenus *Kobeltia* described here has a number of features in common with the widespread European species *Arion distinctus* and *Arion hortensis*. Externally all three are moderate to small in size, possess cryptic dark colouration, have lateral banding, and coloured sole mucus and a dark head and tentacles. Internally the large tripartite free oviduct with strongly developed ligula in the distal section, papillate epiphallus and long vas deferens are shared. The difficulties of distinguishing cryptic



species in this group should therefore not be underestimated. A cursory electrophoretic comparison with related species in the *hortensis* group was undertaken at a very early stage of this study and indicated that *occultus* is a genetically distinct taxon (Dolan & Fleming 1988). This work, however, needs to be repeated in more detail.

*Arion occultus* differs from other *Kobeltia* in its ability to more nearly form a bell shape at rest, and in its strong, rugose, dorsal tuberculation, the absence of an epiphallus structure and in the production of a simple spermatophore. *Arion intermedius* also has a simple spermatophore (Garrido *et al.* 1994) and assumes a foreshortened bell shape at

TABLE 1  
Comparator of British Isles *Kobeltia*

Character	<i>A. occultus</i>	<i>A. hortensis</i>	<i>A. distinctus</i>	<i>A. owenii</i>	<i>A. intermedius</i>
Adult profile at rest	Bell-shaped or flattened	Flattened	Flattened	Flattened	Bell-shaped (but size small!)
Tuberculation	Strong, ridged	Weak, ridged	Weak, ridged	Moderate, ridged	Strong, drawn to a point
Tentacle colour	Black, blue-black	Black, red-tinged	Black, blue-black	Violaceous, purplish tinge	Dark grey or violaceous
Foot fringe colour	Unmarked orange	Orange, spotted or dark at tail	Orange, spotted or darker at tail	Orange, striped or spotted at tail	Unmarked orange
Sole mucus	Weak orange, easily removed	Strong orange, red-orange, persistent	Strong or weak orange, persistent	Strong or weak orange, persistent	Orange, persistent
Dorsal yellow chromatophores	Always strongly developed	Weak or absent	Strongly (mostly) or weakly developed	Present but not obvious	Present but not obvious
Overall colour	Yellowish-brown	Dark grey (bluish in juveniles)	Variable, yellowish-brown to black	Rich fulvous brown to yellowish brown	Pure white or orange; or brownish, with bands
Banding	Dark, broad, high	Dark, low, with paler 'shadow' band above	Dark, low, with paler 'shadow' band above	Dark, high, but diffuse and extending down to the foot fringe	Usually absent; otherwise brown, thin
Epiphallus process	Absent	Oblong plate, covering half of epiphallus outlet (Backeljau & Van Beeck 1986)	Conical, with a lateral channel, covering all of epiphallus outlet (Fig. 3)	Variable but usually elongate, tongue-like (Backeljau & Van Beeck 1986)	Very small, but elongate and tongue-like as in some forms of <i>owenii</i> (Backeljau & Van Beeck 1986)
Spermatophore	Tubular and broad; no serrations present; apex acute	Tubular and broad; serrated keel on full length of one side; apex flattened	Tubular but slender; serrated keel absent.; apex acute	Tubular and broad; serrated keel on full length but spirally twisted; apex acute	Tubular and slender; serrated keel generally absent; apex acute (Garrido <i>et al.</i> 1994)

rest emphasising its prominent tuberculation. However, although presumably closely related to *occultus*, it differs in having an epiphallus structure, albeit poorly developed, in not possessing a ligula and in its much smaller body size. Also, the tubercles are drawn to a point, rather than keeled.

The use by *occultus* of a hibernaculum might suggest a montane origin. There is another European montane species, *A. alpinus*, which has a strong, rugose dorsal tuberculation but this does not belong to the *hortensis* group and lacks a ligula, as well as having a very different, fore-shortened distal oviduct (Wiktor 1996).

The ease with which the cryptic members of *Kobeltia* may be confused and therefore misdetermined or overlooked, suggests that there may be other undescribed species in Europe. This has been alluded to by Falkner *et al.* (2002) among others. However, as Davies (1977, 1979) has illustrated, detailed life history studies and more rigorous internal examination are required to adequately characterise taxa in this group. By such means more insight may be gained into internal relationships within the family and into the scope of its evolutionary direction.

### ACKNOWLEDGEMENTS

I wish to acknowledge the invaluable advice and assistance on many matters relating to the taxonomy of the Arionidae, of Miss S. M. Davies, Croydon. Thanks also to Mr Dave McCall, Applied Plant Science, Newforge Lane and to the Department of Agriculture and Rural Development, Northern Ireland (DARDNI), for the provision of SEM images of the radula of *A. occultus*, which enabled accurate measurements to be made. I am also grateful to Dr. Colin Fleming, Applied Plant Science, DARDNI for including *A. occultus* in an electrophoretic comparison with other *Kobeltia*, soon after its original discovery.

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Plate 1 *Arion occultus* at rest showing the bell-shaped profile and sharp, irregular tuberculation dorsally.



Plate 2 *Arion occultus* in motion showing the blue-black tentacles, yellow dorsal pigmentation and pale sides below the lateral bands.



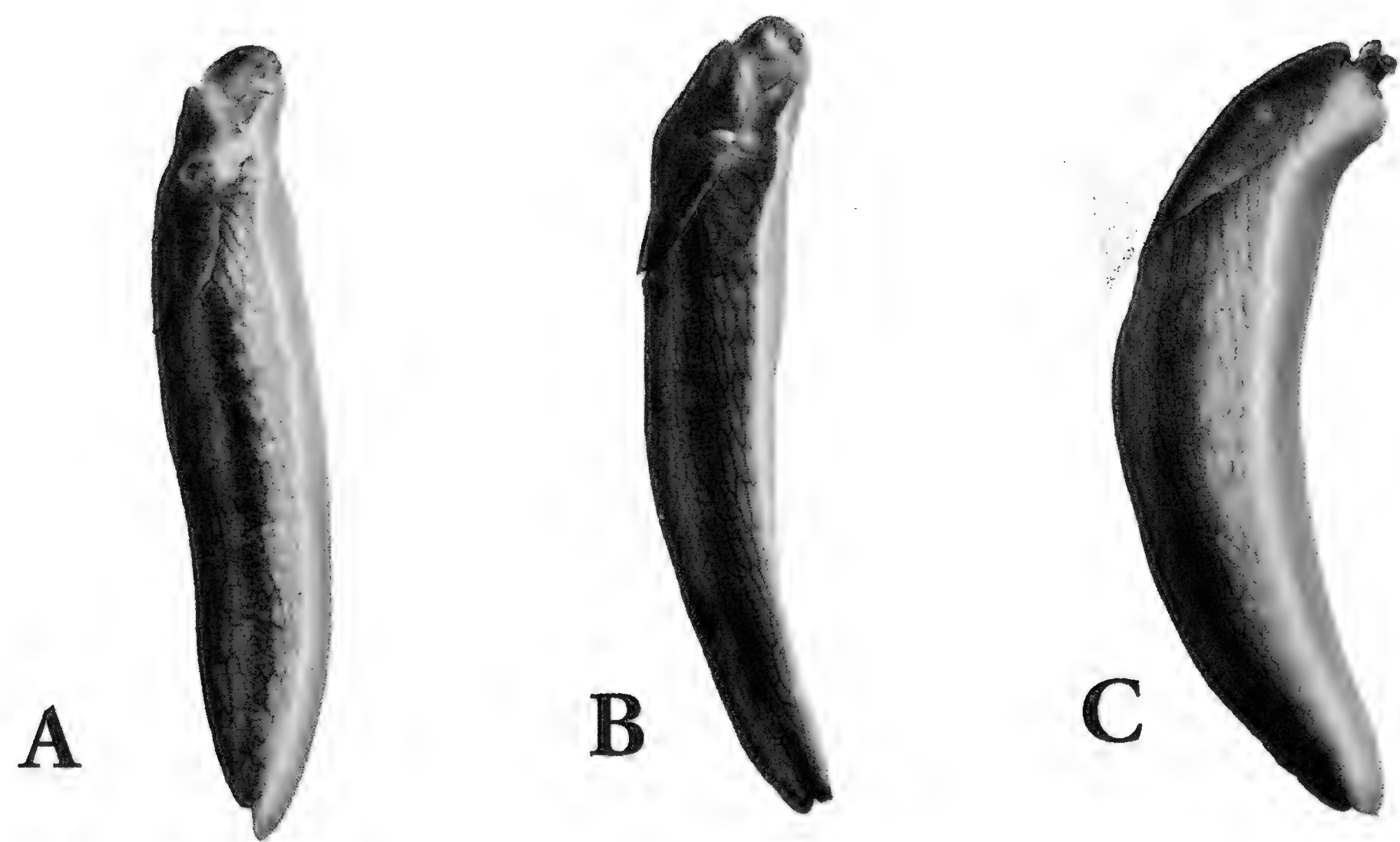


Plate 3 Alcohol specimens of *Arion hortensis* (A), *Arion distinctus* (B) and *Arion occultus* (C) in profile for comparison.



Plate 4 Mating pair of *Arion occultus* to show the size and activity of the ligulae. Note also the clear orange foot fringe of the larger individual.





Plate 5 Mating pair of *Arion occultus* to show protruding spermatophores, post-separation (red arrow).



Plate 6 *Arion occultus* at rest in a soil/mucus cocoon, used for hibernation/ aestivation.





# DESCRIPTION OF A NEW *CYSTISCUS* (GASTROPODA: CYSTISCIDAE) FROM THE MASCARENE ISLANDS.

FRANCK BOYER<sup>1</sup>

**Abstract** *Cystiscus viaderi* sp.nov. is described from the Mascarene Islands. The external morphology and the radula are presented and compared with those of related species. Information on its habitat, distribution and behaviour is given. The features shared by *Cystiscus* species are discussed and some criteria usable for subgeneric attributions are tentatively suggested.

**Key words** *Gastropoda, Cystiscus, taxonomy, anatomy, diversity, Mascarene Islands, Indo- Pacific.*

## INTRODUCTION

In his catalogue from 1937, R. Viader gave a list of 32 valid names and synonyms of marginelliform gastropods said to range throughout Mauritius and its dependencies, including Seychelles Islands, Agalega, Cargados and Rodrigues.

The marginelliform fauna from the Mascarene Islands *sensu stricto* (La Réunion, Mauritius and Rodrigues) has not been revised since this time, but field observations conducted by the author in Mauritius and Rodrigues during 1991 and 1992, together with the complementary study of the recolts made in La Réunion and Mauritius by M. Peyrot-Clausade (MNHN collections) and by M. Jay (La Réunion), lead to consider that a total of 17 valid marginelliform species ranging throughout the Mascarene Islands have already been described, all from shells sampled in beach drift from the archipelago, or from other places in the Western Indian Ocean :

*Closia sarda* (Kiener,1834)  
 «*Serrata*» *delessertiana* (Recluz,1841)  
*Serrata serrata* (Gaskoin,1849)  
 «*Serrata*» *sordida* (Reeve,1865)  
*Volvarina* cf. *compressa* (Reeve,1865)  
*Dentimargo pumila* (Redfield,1870)  
*Marginella picturata* Nevill & Nevill,1874  
*Granulina pulvis* (Jousseume,1875)  
*Gibberula asellina* Jousseume,1875  
 «*Dentimargo*» *nevillei* (Jousseume,1875)  
*Hydroginella osteri* (Jousseume,1875)  
 «*Volvarina*» cf. *amydrozona* (Melvill,1906)  
*Gibberula louisae* (Bavay,1913)  
*Granulina atomella* (Bavay,1917)  
*Marginella ansonae* (Clover,1974)  
*Dentimargo zanzibarica* Bozzetti,1997  
*Closia giadae* Cossignani,2001.

These species represent the majority of the marginelliform gastropods actually living in the upper infralittoral (0-20m) from the Mascarene Islands, several of them being found from La Réunion to Rodrigues, with others ranging as far as Western Madagascar and the Comores Islands. The revision of these species is presently under study, on the basis of new documentary evidence about the external anatomy of the animals and their radulae.

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In the course of this work, several undescribed marginellid species occurring in the upper infralittoral of the Mascarene Islands have been recognized. Among them, the first *Cystiscus* species ever recorded from the Central Indian Ocean, which is described and commented upon below.

#### ABBREVIATIONS

spm : live specimen  
 sh : dead collected shell  
 ad : adult specimen  
 juv : juvenile specimen  
 MNHN: Muséum national d'Histoire naturelle, Paris  
 AWC : A. Wakefield collection  
 JCC : J. Colomb collection  
 JPC : J. Pelorce collection  
 TMCC : T. McCleery collection  
 FBC : author's collection.

#### SYSTEMATICS

CYSTISCIDAE Stimpson, 1865  
 CYSTISCINAE Stimpson, 1865  
 Genus *Cystiscus* Stimpson, 1865

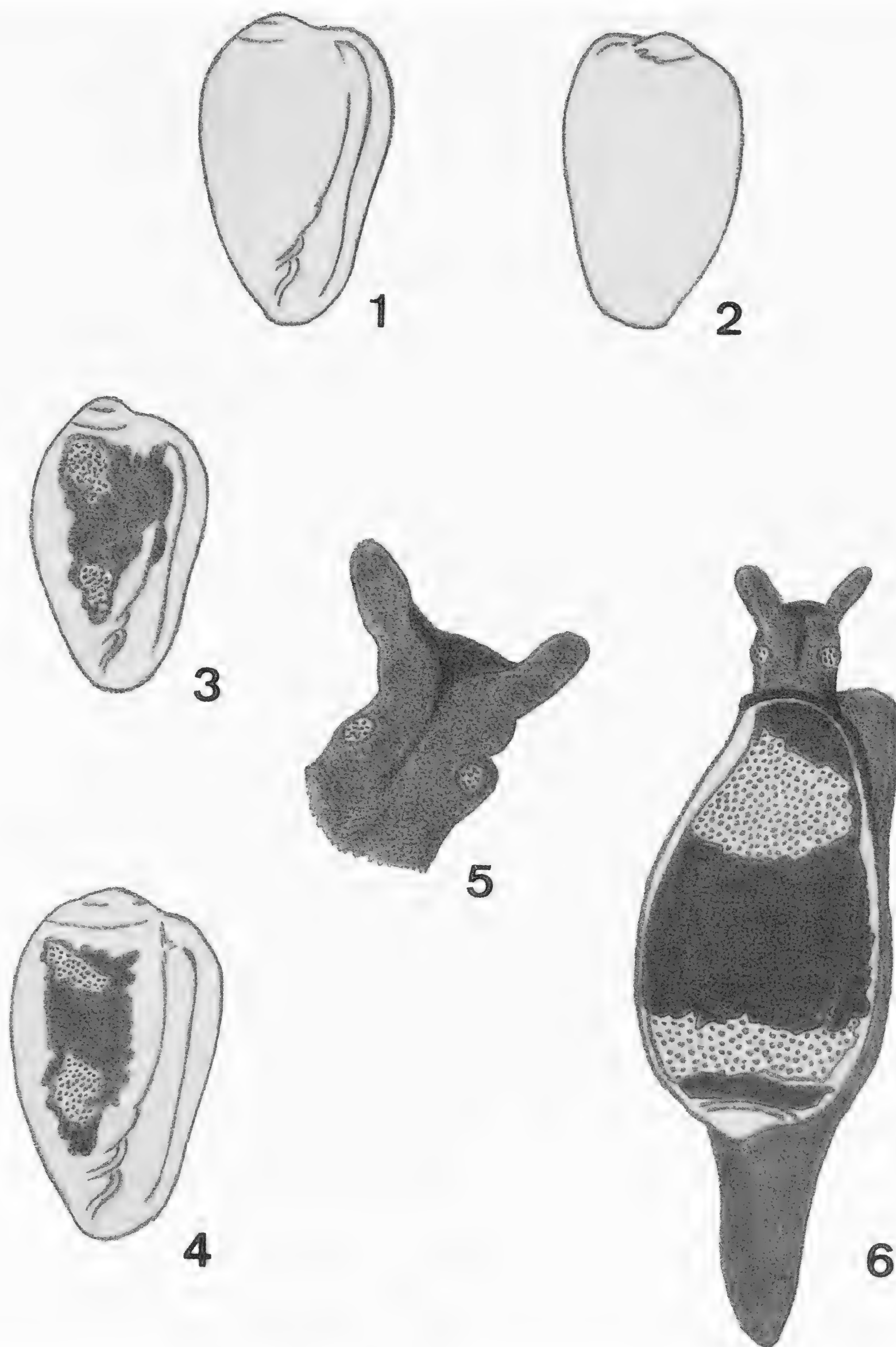
*Type species* *Cystiscus capensis* Stimpson, 1865 (non *Marginella capensis* Krauss, 1848), = *Marginella cystiscus* Redfield, 1870 (nom. nov.); original designation by monotypy.

#### *Cystiscus viaderi* sp.nov. (Figs.1-7)

*Type material* Holotype (Figs.1-2) 1.5 x 0.85 mm and paratype (L=1.5mm), Flic-en-Flac, Mauritius, recolt of the author, beached shell grit, august 1991. Holotype in MNHN, paratype in FBC.

*Other material examined* 2 ad spm (Figs.3-4), height 1.4 and 1.8mm, Flic-en-Flac, Mauritius, 0.5 m at low tide, recolt of the author, 13.3.92, FBC. 6 ad spm and 5 juv spm, Ile Plate, Mauritius, height 1.3 to 1.6 mm, 1 m to 1.5 m at low tide, recolt of A. Wakefield, 18-12-00 : 3 ad spm and 2 juv. spm in AWC, 2 ad spm in TMC, 1 ad spm in FBC, 3 juv spm used for radula extraction. 2 ad spm, Flic-en-Flac, Mauritius, low tide, recolt of A. Wakefield, 12-00, AWC. 6 ad spm and 1 ad sh, La Réunion, lagoon, low tide, recolt of M. Jay, FBC. 2 ad spm, Mayotte, 3 m, FBC. 1 ad spm, Moya Petite Terre, south beach, Mayotte, 0-3 m at low tide, recolt of J. Pelorce, 15-11-97, JPC. 1 ad sh, Latundo Kecil, Taka Bonerate, Flores Sea, Indonesia, in caves on wall, 10-35 m by diving, 7-10-01, JCC.

*Description* (holotype, Figs.1-2) Shell minute, light, hyaline, whitish, glossy ; outline obovate, tapering to the base ; spire low and obtuse, apical angle 120°; teleoconch made of 2 whorls, sutures merged and indistinct ; labial lip faintly thickened, sinuous, smooth ; external varix absent ; siphonal and posterior notches absent ; labial shoulder slightly elevated, aperture narrow, expanding in its anterior third part ; parietal wall smooth, columella triplicate, the first plait strong and sinuous, the second short and oblique, the posterior one being very long and oblique, but faintly prominent and almost merged in



**Figs 1-6** 1-2 *Cystiscus viaderi* sp.nov., holotype. 3 *Cystiscus viaderi* sp.nov., "male" phena, Flic-en-Flac, length 1.4mm. 4 *Cystiscus viaderi* sp.nov., "female" phena, Flic-en-Flac, length 1.8 mm. 5 *Cystiscus viaderi* sp.nov., detail of the head. 6 *Cystiscus viaderi* sp.nov., live animal.

the outline of the parietal wall.

Type 3 animal (*sensu* Coover, 1987) (Figs.5-6) with a split head, protuberant anterior lobes, eyes on lateral swellings, foot simple, narrow, flat, propodium truncated, metapodium moderately lengthened, gently rounded at the tip. No apparent siphon. The head and the foot are blackish to jet black, the eyes are deep tyrian pink, the internal mantle showing through as 3 black zones alternating with 2 deep orange zones, the external mantle is black and smooth. In blackish coloured animals, the posterior border



of the metapodium and the median line may be darker.

**Radula** : only one radula was successfully extracted and mounted, from a juv spm of 1.2 mm of length (Fig.7). The radula is very small, narrow and long, counting 150 plates. Each plate is 7,5µ of width. It bears 4 prominent tubercles, the 2 central ones being rounded (one larger than the other one), the 2 lateral ones sharper and laterally oriented.

**Habitat** In short algae and moss under coral slabs and boulders. The specimens are generally found in pairs, with one of the specimens being appreciably larger (Figs.3-4).

**Distribution** *C. viaderi* sp. nov. is known from Mauritius and La Réunion. The limited samplings made in Rodrigues did not allow verification of the species occurrence there. However, it must be noted that most of the marginellid species living in the upper infralittoral from Mauritius are also found in Rodrigues (recolts of J. Colomb and of the author).

The specimens from La Réunion may present a more slender and subcylindric outline. One subadult specimen just shows 2 columellar plaits, one adult shows 4 plaits, the upper one being thin, long and perpendicular to the parietal border, and looking like a parietal liration.

The 3 specimens studied from Mayotte show the same general shell morphology and internal mantle as the specimens from Mascarene Islands. However, 2 of these 3 specimens show numerous parietal lirations (3 to 4) in addition to the 3 basal columellar plaits. This character may well be a feature of the natural variation of the shell morphology in Mascarene populations too, but the limited number of specimens examined doesnot allow a conclusion on this point, no more than can be said about a possible geographic intraspecific variation expressed west from Madagascar.

Even if the belonging of the population from Mayotte to our new species is very probable, it seems more adequate for now to refrain its formal placement until there has been a full verification of the animals soft parts from this locality, and a more extensive control of the variation of the shell morphology of the species has been performed.

Very few *Cystiscus* have been described from the intertropical Western Indian Ocean. *Cystiscus gibberuliformis* (Bozzetti,1997), described from Zanzibar, is also found in Mayotte together with *C.cf. viaderi* (recolt of J.Pelorce) without intergrades. *C. gibberuliformis* is larger (length : 1.9 to 2.1 mm), slender and narrowed, with a very inflexed labrum, a more hooked anterior outline, and a wide and rounded siphonal canal. All 5 type specimens are said to bear 4 well defined columellar plaits. The first plait is almost vertical and not sinuous.

*Cystiscus gennesi* (H. Fischer,1901), only known by its holotype from Djibouti (MNHN type collection), principally differs from *C. viaderi* by its high and inflated spire which constitutes 30 % of the total length. The first columellar plait is long and presents a steep rupture of its profile towards its base, and the lower half part of the aperture is widely dilated.

None of the species revised or described from South Africa by Lussi and Smith (1998) show close similarities with *C. viaderi*.

The shell recorded above from Indonesia is perfectly similar to shells of *C. viaderi* from the Mascarene Islands. However, the internal mantle was not conserved and its identification as our new species remains provisional. It must be noted that such occurrences in Indonesia and Cocos-Keeling Islands of marginellid species which also inhabit the Mascarene Islands are commonly verified in literature or in collections (see in Maes, 1967 for *Granulina* cf. *atomella*, *Volvarina* cf. *compressa* and *Dentimargo* cf. *pumila*).

**Derivation of name** From René Viader, a Mauritian student who performed, from the

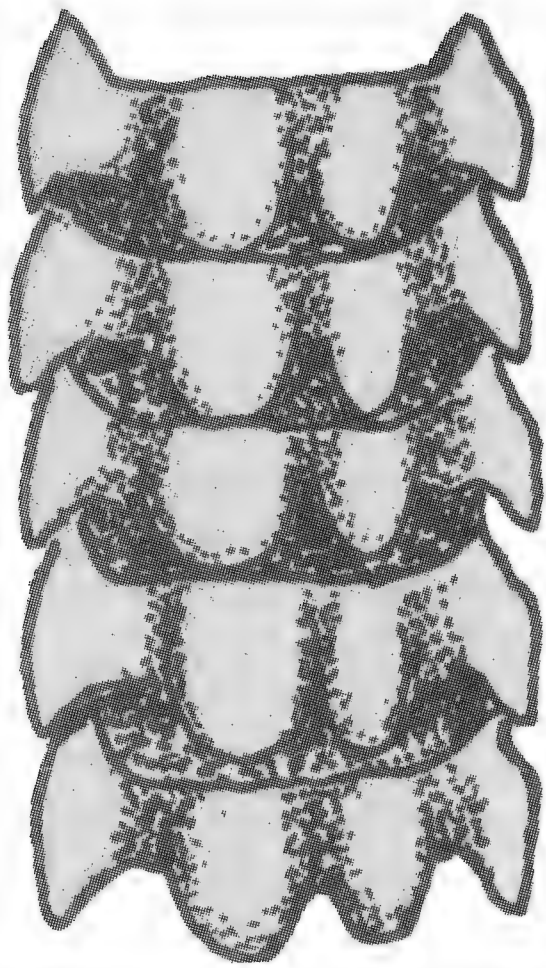


Fig. 7 Radula of *C. viaderi*.  
Scale bar = 10  $\mu$ .

thirties to the fifties, the first advanced inventories and critical revisions of the molluscan fauna from the Mascarene Islands.

## DISCUSSION

All these records and informations about *C. viaderi* sp.nov. allow a reassessment of the features which could characterize the genus *Cystiscus* itself.

Coover & Coover (1995) report that the head and the mantle of *Cystiscus* are uniformly coloured, generally in intense tones. They also explain that the colour pattern of the internal mantle is often seen through the shell, but they are not more precise. In fact, Coover & Coover report that the study of the soft parts has been carried out for 13 unnamed species of *Cystiscus*, considered as an undifferentiated whole.

The high diversity of the chromatism of the soft parts in *Cystiscus* must be emphasized, not only from the point of view of the colour, but also in the

pattern of decoration. Owing to the often very similar shells found in *Cystiscus* species, the chromatism of the soft parts must be used as a major character for the determination at the specific level, and possibly to a subgeneric level. For instance, 5 undetermined species of *Cystiscus* from New Caledonia (Expedition Montrouzier) are presented with their soft parts in Bouchet (1994 : 37, drawings by S. Gofas) : these 5 species include 2 pairs of sibling species, apparently inseparable on the basis of their shell morphology alone. Their identity as species seems to be more firmly established by the chromatism of the soft parts, which is very original and constant in each phenon (S. Gofas, pers. comm.).

In some cases, the knowledge of the chromatism of the soft parts will be the only means by which the species can be identified. For instance, two similar phenae of minute short subtriangular shelled *Cystiscus* (one much larger than the other one) are separated in shell grit from La Réunion. Similar shells are found in Mayotte. Owing to their mutual resemblance and to their similarity with other subtriangular shelled phenae from South Africa, New Caledonia and French Polynesia, a correct specific attribution await complete documentation on the live animals.

It is also possible that phyletic groups of *Cystiscus* might be distinguished on the basis of similar kinds of chromatism of the soft parts. For instance, *C. viaderi* shows the same kind of chromatic pattern of the soft parts as a species found in the Society Islands (Raiatea, Moorea and Tahiti, pers. comm. from P. Festou and T. McCleery; description by T. McCleery and A. Wakefield in press), the difference laying not principally in the fact that the Polynesian species is yellow and black coloured instead of orange and black in *C. viaderi*, but overall in the fact that the Polynesian species possesses a sixth anterior band of yellow colour and that the head and the foot, in continuity, are also yellow instead of black in *C. viaderi*. The shell morphologies of both species are similar and a close relationship between them can be supposed.

The eye colour seems to be a common feature shared by all *Cystiscus* species. Coover (1987) reports the eyes colour for 5 species attributed to *Cystiscus*. Among these 5 species, 4 have red eyes and are associated with the typical bifurcate head of *Cystiscus*. The other species, as *Cystiscus alborubida* (Barnard, 1969), has black eyes associated with

"tentacles", which are absent in the real *Cystiscus*. Furthermore, the bifurcate head is not mentioned in the description "*C. alborubida*". This species might better belong to the genus *Plesiocystiscus* Coover & Coover, 1995, if not to another genus.

It must be noted that all the 5 species of *Cystiscus* illustrated by Gofas in Bouchet (1994) have red eyes. It is also the case in the *Cystiscus* sp. quoted above from French Polynesia. Another undescribed species from Tuamotu Islands (pers. comm. from T. McCleery) shows also red eyes.

On the basis of their radulae, *Cystiscus* species seem to be somewhat diversified too. Coover & Coover (1995) quotes the study of the radula in 14 unreferenced species. Earlier, Coover (1989 : 5-6) merely reported the figures of 3 radulae of *Cystiscus*, which show a similar pattern of slightly arched plates bearing 7 to 10 sharp and rather asymmetric cusps. A fourth species was reported without a figure, as having a radula of 100 crescentic and concave plates of 5 cusps.

In accordance with previous records, the radula of our new species comprises a great number of 4 cusped plates, but these plates are not visibly arched and their two central asymmetric cusps are very rounded. Further investigations might reveal that several phyletic (or non-phyletic) groups can be distinguished among *Cystiscus* on the grounds of their similar radulae.

The discovery of most specimens of *C. viaderi* in pairs isolated under a coral slab might correspond to a constant behaviour in the species. The same observation was made about the *Cystiscus* sp. quoted from the Society Islands (pers. comm. from P. Festou). In each case, the pair of specimens is composed of individuals showing an important difference in size. It can be reasonably inferred that these pairs are couples (the female being normally larger in marginelliform gastropods), and the frequency of their occurrence allows us to presume that these couples are lastingly formed. This behaviour feature may be constant in the genus, or at least in a "*C. viaderi* group" which remains to be fully defined.

### ACKNOWLEDGEMENTS

I am indebted to Andrew Wakefield (UK), Patrick Festou (Society Islands) and Tony McCleery (Guernsey) for their accurate observations in the field, and for the gift of material for study. Jacques Colomb (France), Jacques Pelorce (France) and Maurice Jay (La Réunion) also contributed by the loan or the gift of material and by their personal records.

A special thanks is due to Dario David (Mauritius) who helped much in the field, to Emilio Rolan (Spain) who extracted and drew the radula, and to Isabelle Boyer (France) who typed up the manuscript. Andrew Wakefield dauntlessly corrected the English form.

Thanks to the Mauritius Institute for its warm welcome. The Mauritius Ministry of Agriculture kindly gave authorisation for field sampling.

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# THE RELATIONSHIP BETWEEN ABUNDANCE AND PREVALENCE OF TREMATODE PARASITES INFECTING *LYMNAEA STAGNALIS* L.

ROBERT A BRIERS<sup>1</sup>

*Abstract* The relationship between the prevalence and abundance (infection intensity) of trematode parasites infecting *Lymnaea stagnalis* L. was investigated based on collections of snails from 12 sites in central UK. Five species of trematode were recorded from the snails. There was a significant positive relationship between the prevalence and abundance (intensity of infection) of trematode species.

*Key words* *Lymnaea stagnalis*, parasitism, occupancy-abundance relationship.

## INTRODUCTION

A positive relationship between the local abundance attained by a species at any given site and the extent of the species distribution has been widely observed in nature (Brown, 1984; Gaston *et al.*, 1997; Gaston & Blackburn, 2000). For parasites, this relationship equates to a positive relationship between the intensity of infection (number of conspecifics per host) and prevalence of infection (the proportion of hosts in a population which are infected). A positive relationship has been documented for parasites of birds, mammals and fish (Poulin, 1999; Morand & Guegan, 2000; Simkova *et al.*, 2002) but the generality of the relationship for parasite species remains unclear, in part due to the small number of studies that have examined the patterns.

Freshwater gastropod snails of the genus *Lymnaea* are common primary hosts for a range of parasitic trematode worms (Adam & Lewis, 1993; Sorensen & Minchella, 1998; Zakikhani & Rau, 1999; Loy & Haas, 2001). Trematodes have complex lifecycles involving between one and three intermediate hosts, prior to infection of the definitive host (commonly a bird or amphibian), but essentially all trematode species require an aquatic mollusc as primary intermediate host (Esch & Fernandez, 1994). Snails are infected through ingestion of eggs deposited in the faeces of the definitive host, or are penetrated by motile miracidia which hatch from the eggs in some species.

There is wide variation in the prevalence and intensity of trematode infection exhibited by different populations of molluscan hosts (Kuris & Lafferty, 1994), but whether the two variables are related has not been examined. Here the relationship between the abundance (intensity) and distribution (prevalence) of trematode parasites in populations of the great pond snail, *Lymnaea stagnalis* L. (Gastropoda: Pulmonata) is examined.

## METHODS

Snails were sampled in July 2002 from 12 sites (canals or lakes) in central UK. The sites were arranged on an East-West transect as part of a study into geographical variation in parasite prevalence in snail populations. Further details of the locations sampled are given in Briers (2003). Here data from the 12 sites were pooled to examine patterns across all populations. Snails were collected with a hand net from a 100m stretch of

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bank, in order to minimise the influence of local variation in parasite prevalence on the results. The number of snails collected at each site varied between 56 and 121; the total number of snails examined was 838.

Within 48 hr of collection, snails were screened for trematode infection in the laboratory by isolating them individually in 50ml glass vials containing 20ml of filtered water from the site where the snails were obtained. The snails were held under approximately 7000 lux illumination at 20°C for 12 hr to stimulate the production of cercariae, the motile stage of the trematode responsible for infection of the next host (Minchella *et al.*, 1985; Brown *et al.*, 1988), which were subsequently identified to species. Prevalence was calculated in two ways: first as the number of infected snails divided by the total number of snails examined; second as the mean of prevalences recorded in each population. Analyses using both measures gave identical results and hence only the first measure of prevalence is reported here. The number of cercariae produced during screening was used as a measure of infection intensity (c.f. Zakikhani & Rau, 1999). Following screening, snails were removed from the vials, and the number of cercariae produced quantified by removing a 1ml sample from the 20ml of water, after thorough mixing. The sample was placed in a Sedgewick-Rafter slide and the number of cercariae counted under a light microscope. For the purposes of analysis, a mean intensity was calculated for each parasite species recorded. Prevalence data were arcsine square root transformed and intensity data natural log transformed (Zar, 1996).

## RESULTS

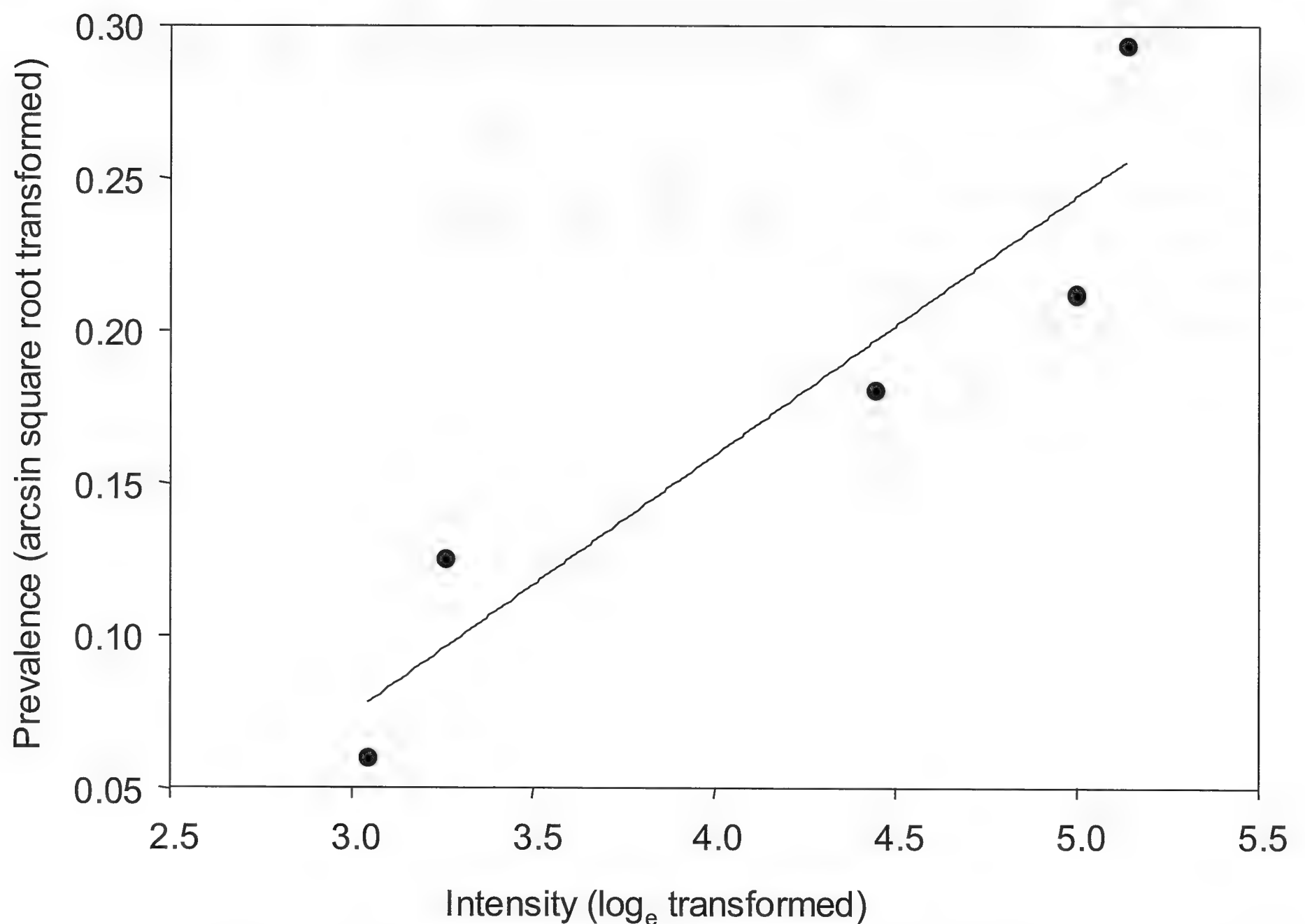
Five species of trematode parasite were recorded from *L. stagnalis* at the sites sampled. In order of decreasing prevalence they were: *Diplostomum spathaceum* Rudolphi, *Echinostoma revolutum* Fröelich, *Echinoparyphium recurvatum* von Linstow, *Cotylurus brevis* Dubois and Roach and *Cercaria edgbastonensis* Nasir.

There was a significant positive relationship between prevalence and intensity of infection for the trematode species infecting *L. stagnalis* ( $\arcsin \sqrt{\text{prevalence}} = 0.084 \times \log_e \text{intensity} - 0.181$ ,  $F_{[1,3]} = 21.15$ ,  $P = 0.019$ , adjusted  $r^2 = 0.834$ , Fig. 1). The number of cercariae produced by infected snails is known to vary with snail size but there was no significant difference between the sizes of snails infected by different trematode species (ANOVA,  $F_{[4,145]} = 0.05$ ,  $P = 0.994$ ), suggesting that differences in snail sizes did not contribute to the observed pattern.

## DISCUSSION

In the populations of *L. stagnalis* surveyed for this study, parasite infection intensity and prevalence were positively related. This is consistent with other studies of parasite species in other animal groups (Poulin, 1999; Morand & Guegan, 2000; Simkova *et al.*, 2002), but this is the first time that the relationship has been established for species of trematodes infecting lymnaeid snails.

Whilst a positive relationship was revealed, the number of species of trematode recorded from the populations of *L. stagnalis* was small, limiting the power of the study. An additional problem is the determination of infection intensity. Cercarial production is generally positively related to infection intensity in trematodes (Zakikhani & Rau, 1999), but there are a number of other factors that may influence cercarial production, such as host age on infection (Zakikhani & Rau, 1999) and host nutrition (Keas & Esch, 1997), which could not be controlled for in the current study. There are several different



**Fig. 1** The relationship between average infection intensity and prevalence of five species of trematode infecting *L. stagnalis*. Fitted line represents a linear regression equation; see text for details of equation.

routes by which the intra-molluscan stages develop (by the production of redia or sporocysts) and asexual reproduction by the different intra-molluscan trematode stages (Esch & Fernandez, 1994) has a massive influence on cercarial production.

The positive correlation between distribution and abundance has been widely reported, and a number of hypotheses have been suggested to explain the pattern (Gaston *et al.*, 1997), some of which have been tested for parasite species. In the case of parasites, the direction of causation of the positive correlation is potentially problematic. Most hypotheses assume wide distribution results in greater abundance (Gaston *et al.*, 1997). For trematode parasites in snails, it is possible that the causation is reversed. Cercarial production is dependent on a wide range of factors (Esch & Fernandez 1994, Keas & Esch, 1997, Zakikhani & Rau, 1999) but those individuals that produce the most cercariae are likely to infect more secondary intermediate and thus final hosts. A higher number of infected final hosts will produce more eggs, and potentially result in higher local prevalence. This potential mechanism for generating positive correlations between intensity and prevalence warrants further study.

In the context of parasites, most attention has been focused on the resource specialization, or niche breadth hypothesis (Brown, 1984), which predicts that parasite species able to exploit a wide range of host species will be more widely distributed and hence more abundant at the local scale. The limited range of studies that have examined niche breadth of parasitic species have generally found evidence in support of this hypothesis (Poulin, 1999; Simkova *et al.*, 2002), although a study of fish parasites found a negative relationship between abundance and host specificity (Poulin, 1998). Information on the range of primary host snails used by the species of trematode recorded here is incomplete, preventing any analysis of the possible effects of host

specificity on prevalence and intensity of infection.

An additional complicating factor is the multi-host nature of trematode lifecycles. Many species infect more than one intermediate host prior to entering the definitive host (Esch & Fernandez, 1994), and parasite specificity may vary at each stage. It is therefore difficult to assess at which stage to examine host specificity. There is some evidence that local trematode distribution and abundance in snail hosts is influenced by the distribution of definitive hosts (Smith, 2001), but physicochemical conditions experienced by snails or other intermediate hosts may also influence parasite prevalence (Kiesecker & Skelly, 2001).

Due to the limited scope of the present study, it is not possible to assess further the possible role of alternative mechanisms that may result in the observed patterns. However it is clear that there is a positive relationship between the prevalence and intensity of trematode infection in populations of *L. stagnalis*, consistent with other studies of parasitic species (Poulin, 1999; Morand & Guegan, 2000; Simkova *et al.*, 2002), and more generally (Gaston & Blackburn, 2000).

### ACKNOWLEDGEMENTS

This study was funded by a research grant from the Conchological Society of Great Britain and Ireland; the support of the Society is gratefully acknowledged. I would also like to thank the various landowners who allowed me to sample on their land.

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# ADELOPOMA PERUVIANUM NEW SPECIES FROM NORTHERN PERU (GASTROPODA: DIPLOMMATINIDAE)

BERNHARD HAUSDORF<sup>1</sup> & SAMIRA GUEVARA MUÑOZ<sup>2</sup>

*Abstract* *Adelopoma peruvianum* n. sp. from the Departamento San Martín in northern Peru is characterized by widely spaced ribs, a distinct bulge on the body whorl, a columellar lamella and a distinct perforation.

*Key words* *Adelopoma*, *Diplommatinidae*, *systematics*, *Peru*

## INTRODUCTION

*Adelopoma* Döring, 1884 is the only genus of the Diplommatinidae that occurs in America. It is distributed from Mexico through Central and South America to Argentina. Until recently the following six species were known: *Adelopoma stoll*i (Martens, 1890) from Mexico and Guatemala, *Adelopoma costaricense* Bartsch & Morrison, 1942 from Costa Rica, *Adelopoma occidentale* (Guppy, 1872) from Trinidad, *Adelopoma bakeri* Bartsch & Morrison, 1942 from Venezuela, *Adelopoma paraguayana*m Parodíz, 1944 from Paraguay and Argentina and *Adelopoma tucma* Döring, 1884 from Paraguay and Argentina (Bartsch & Morrison, 1942; Parodíz, 1944; Quintana, 1982). There was also one record from Peru: Ramirez (1991) found an *Adelopoma* species in the nature reserve Cuzco Amazónico (12°35'S, 69°05'W) in the Departamento Madre de Dios in southern Peru which she tentatively identified with *Adelopoma paraguayana*m Parodíz.

The second author recently discovered a new *Adelopoma* species at several sites in the Departamento San Martín in northern Peru which is described in this paper.

## MATERIAL AND METHODS

The counting of the shell whorls (exactness 0.25) follows Kerney & Cameron (1979: 13). The material on which this study is based is kept in the Nationaal Natuurhistorisch Museum, Leiden (NNM), the Senckenberg-Museum, Frankfurt a. M., (SMF), and in the Zoological Museum of the University Hamburg (ZMH).

Additional abbreviations: D = shell diameter; H = shell height (exactness 0.05 mm).

## TAXONOMIC DESCRIPTION

Diplommatinidae L. Pfeiffer, 1857  
*Adelopoma* Döring, 1884

*Adelopoma peruvianum* n. sp.

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*Holotype* Peru, Departamento San Martín: Moyobamba: Jepelacio, Carrizal II, 23 km SE of Moyobamba, 150 m altitude, 06°13'39"S 76°54'54"W (ZMH 10025, leg. S. Guevara 01.03.2001, measurements: D = 1.25 mm, H = 2.4 mm).

*Paratypes* Peru, Departamento San Martín: Rioja: La Primavera, 42 km NW of Moyobamba, 979 m altitude, 05°58'06"S 77°20'08"W (ZMH 10224); Rioja: Cueva Huacharos de la Encañada, 32 km SW of Moyobamba, 600 m altitude, 06°06'39"S 77°14'16"W (ZMH 10122); Rioja: Afluente, Cueva, 91 km NW of Moyobamba, Bosque de Protección Alto Mayo, 1500 m altitude, 05°39'06"S 77°41'40"W (ZMH 10301); Moyobamba: San Marcos, 27 km SW of Moyobamba, 400 m altitude, 06°13'31"S 77°06'51"W (ZMH 10048); Moyobamba: Jepelacio, Carrizal II, 23 km SE of Moyobamba, 150 m altitude, 06°13'39"S 76°54'54"W (ZMH 10013); Moyobamba: Jepelacio, Carrizal I, 22 km SE of Moyobamba, 100 m altitude, 06°13'04"S 76°54'55"W (ZMH 10010).

*Type locality* Peru, Departamento San Martín: Moyobamba: Jepelacio, Carrizal II, 23 km SE of Moyobamba, 150 m altitude, 06°13'39"S 76°54'54"W.

*Shell* (Fig. 1, 3): sinistral; conical; with 5-5.5 strongly inflated whorls separated by a deep suture; protoconch smooth; teleoconch with lamellate ribs (17-20 on the penultimate whorl) and distinct spiral striae between the ribs; white; subtranslucent; body whorl rounded, ventrolaterally with a distinct bulge; aperture almost circular; upper insertion of the peristome not descending; peristome continuous, double, distinctly expanded, weakly thickened; there is a columellar lamella laterally right in the body whorl, which can be seen in the aperture as indistinct tubercle on the columella; perforate.

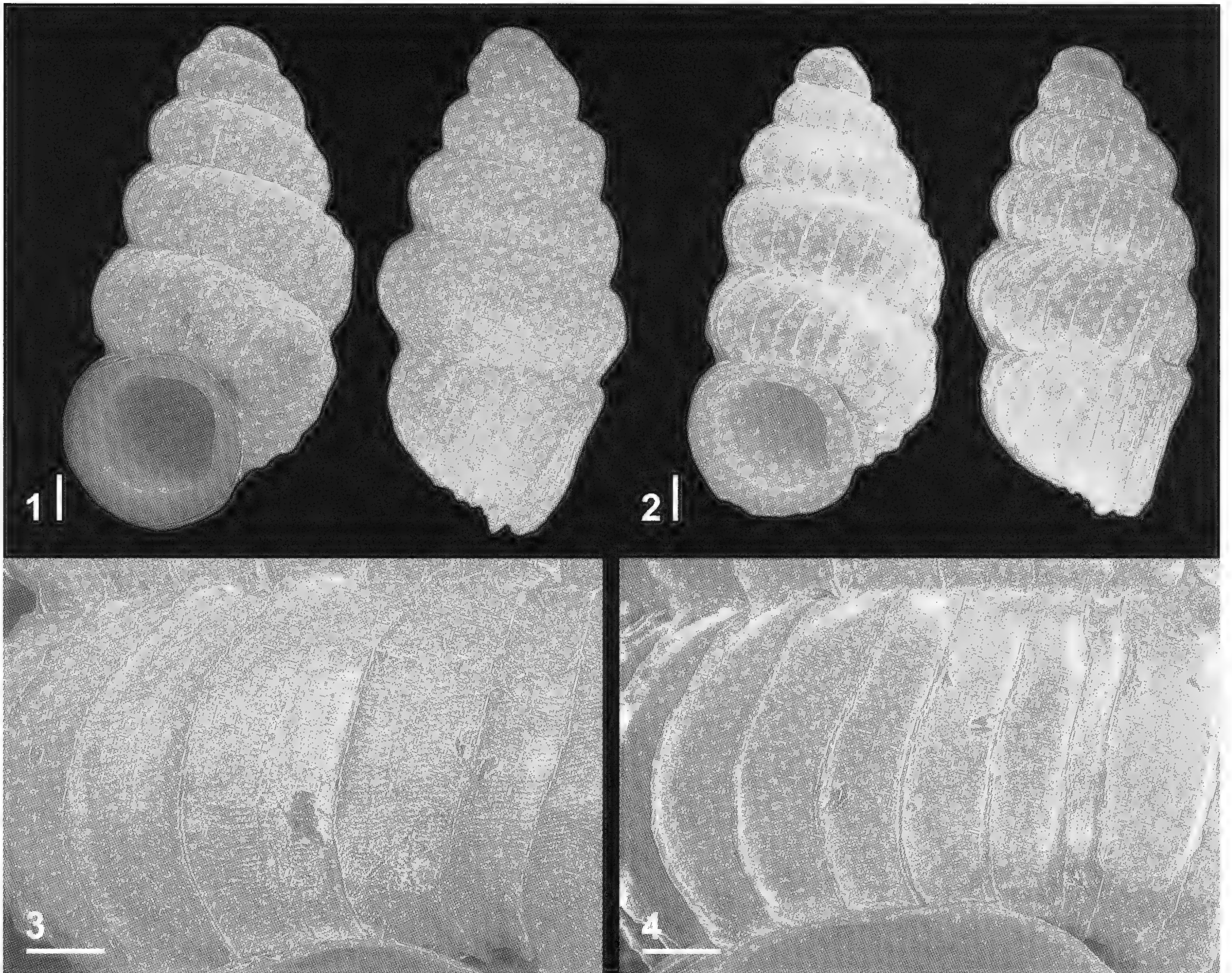
*Measurements* Moyobamba: Jepelacio, Carrizal II (n = 30): D: 1.15-1.3 mm,  $\phi$  = 1.25 mm; H: 2.2-2.6 mm,  $\phi$  = 2.4 mm; D/H: 0.478-0.549,  $\phi$  = 0.522.

*Remarks* *Adelopoma peruvianum* differs from other *Adelopoma* species in the widely spaced ribs, the distinct bulge on the body whorl, the presence of a columellar lamella and the distinct perforation. So far, a tubercle on the columella has been described only in *A. bakeri* (Bartsch & Morrison, 1942). However, it proved to be present also in *A. paraguayana* and it is possible that it has been overlooked in other species, too. Bartsch & Morrison (1942) mention it even in the diagnosis of the genus. The rib density of the shell of *A. peruvianum* is higher than in the imperforate *A. stolli*, but lower than in the other known *Adelopoma* species.

It is possible that the specimens from the nature reserve Cuzco Amazónico (12°35'S, 69°05'W) in the Departamento Madre de Dios in southern Peru which Ramirez (1991) tentatively identified with *A. paraguayana* are conspecific with *A. peruvianum*. *A. peruvianum* differs from *A. paraguayana* (Fig. 2, 4) in the lower rib density (22-27 ribs on the penultimate whorl of *A. paraguayana*), the more distinct incised spiral striae, the more distinct bulge of the body whorl and the on average larger shell (measurements of *A. paraguayana* from Villarrica, Paraguay (n = 6; NNM 1678): D: 1.15 mm,  $\phi$  = 1.15 mm; H: 2.2-2.35 mm,  $\phi$  = 2.25 mm; D/H: 0.493-0.525,  $\phi$  = 0.507).

*Derivation of name* The specific epithet refers to the occurrence of the species in Peru (latin adjective *peruvianus*).

*Distribution* *Adelopoma peruvianum* is known from the Departamento San Martín in northern Peru at 100-1500 m altitude.



**Figs 1-4** *Adelopoma* spp. **1** *Adelopoma peruvianum* n. sp., Peru: Moyobamba: Jepelacio, Carrizal II (holotype ZMH 10025). Scale bar = 0.2 mm. **2** *Adelopoma paraguayana* Parodiz, Paraguay: Villarrica (NNM 1678). Scale bar = 0.2 mm. **3** *Adelopoma peruvianum* n. sp., Peru: Moyobamba: Jepelacio, Carrizal II (holotype ZMH 10025). Microsculpture of the teleoconch. Scale bar = 0.1 mm. **4** *Adelopoma paraguayana* Parodiz, Paraguay: Villarrica (NNM 1678). Microsculpture of the teleoconch. Scale bar = 0.1 mm.

### ACKNOWLEDGEMENTS

We are grateful to Prof. Dr. E. Gittenberger (NNM) for the loan of material and J. Hartmann (University Hamburg) for taking the SEM photos.

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# DISTRIBUTION OF *PISIDIUM GLOBULARE* CLESSIN, 1873 (MOLLUSCA: BIVALVIA) IN THE CZECH REPUBLIC AND SLOVAKIA WITH NOTES TO ITS ECOLOGY AND MORPHOLOGICAL CHARACTERS

MICHAL HORSÁK<sup>1</sup> & KATEŘINA NEUMANOVÁ<sup>2</sup>

*Abstract* In this paper the first particular records of the pill clam *Pisidium globulare* Clessin, 1873 from the Czech Republic and Slovakia are published. All these data were obtained by revision of extensive voucher material (altogether 642 lots from a similar number of sites). Altogether, *P. globulare* was found in 18 sites in the Czech Republic and in one site in Slovakia. Results of pore density measurement and ecological preferences of the species are compared with published data and conclusions are presented.

*Key words* *Pisidium globulare*, *Bivalvia*, *Sphaeriidae*, New records, Distribution, Ecology, Morphology

## INTRODUCTION

One of the most widely distributed and abundant species of the genus is *Pisidium casertanum* (Poli, 1791), formerly considered as a probably cosmopolitan species. Investigations of some authors dealing with characters of pores penetrating the shells show that pore characters must have taxonomic value (e.g. Dudych, 1983; Araujo, 1998). Kuiper and Hinz (1983) used the differences in pore density to distinguish the new species *Pisidium meierbrooki* Kuiper et Hinz, 1983 from *P. casertanum*.

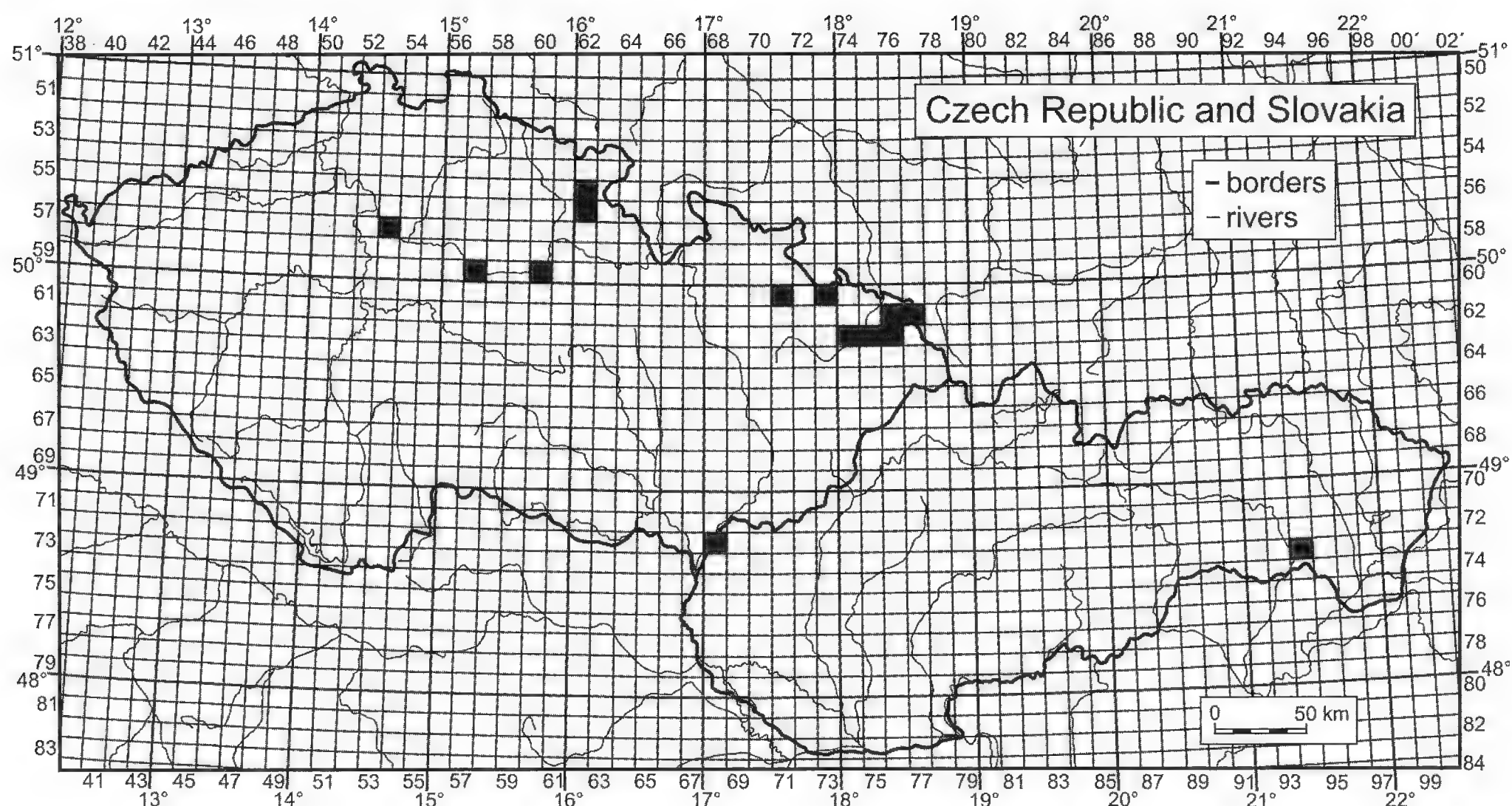
*P. casertanum* is also one of the most variable species of the genus. At least two distinct conchological forms, widely distributed in Europe, were distinguished in the past (Piechocki, 1989): var. *ponderosum* Stelfox, 1918 and var. *globulare* Clessin, 1873. The work of Araujo and Korniuschin (1998) revealed significantly higher porosity of *P. casertanum* var. *globulare*. Furthermore Korniuschin (1992) and Izzatullaev and Korniuschin (1993) found conchological, anatomical and ecological differences. Korniuschin (1998) was the first to suggest that the name *Pisidium globulare* Clessin, 1873 could be assigned to the probably distinct species inhabiting wetlands and widely distributed in the Palaearctic region. This view was confirmed by Korniuschin (1999). *P. globulare* differs from *P. casertanum* by the inflated shell with prominent umbones (Fig. 2), short lateral teeth, dense porosity and large outer demibranch (see Korniuschin, 1998; Glöer and Meier-Brook, 2003). Based on this new information *P. globulare* has been reported from many countries of Europe (e.g. Falkner, Bank and Proschwitz, 2001; Greeke and Kalnins, 2002; Glöer and Meier-Brook, 2003).

The presence of *P. globulare* within the Czech Republic and Slovakia was already published (Falkner, *et al.* 2001; Šteffek and Grego, 2002). In both cases these are check-lists without any particular records. Besides that, no citations of the first records are given. Thus, it is not clear, whether the species was not included only because of results of investigations in adjacent countries. Therefore, a revision of voucher material from the Czech Republic and Slovakia was very desirable.

The purpose of this study is to find out the occurrence and distribution of *P. globulare* in the Czech Republic and Slovakia based on revision of voucher material. The second aim is to compare porosity and ecological characters between *P. globulare* and

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**Figure 1** Present known distribution of *Pisidium globulare* Clessin, 1873 in the Czech Republic and Slovakia.



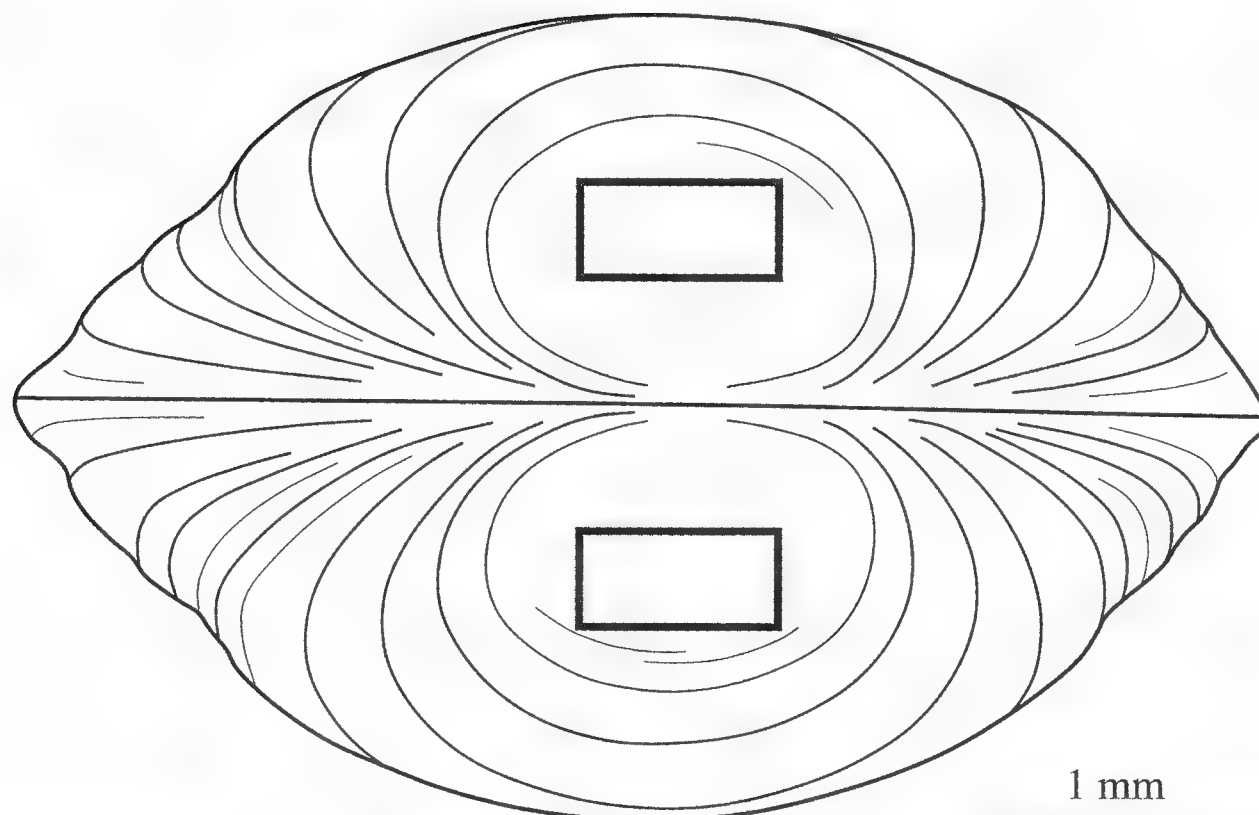
**Figure 2** Adult specimen of *Pisidium globulare* Clessin, 1873 from loc. 20 (see Appendix).

*P. casertanum* from the Czech Republic and Slovakia, and to compare the results with known information from other countries.

## MATERIAL AND METHODS

In this study, voucher material of *P. casertanum* from three collections was revised: SM - collection of S. Mácha deposited in the Silesian Museum in Opava (214 lots examined), JB - collection of J. Brabenec deposited in the National Museum in Prague (245 lots examined), and MH - collection of M. Horsák deposited in Polichno (183 lots examined). Studied material comes from all types of habitats, where *P. casertanum* lives: rivers, canals, brooks, ponds, standing and temporary pools, springs, fens, bogs, swamps, wet





**Figure 3** Adult specimen of *Pisidium globulare* Clessin, 1873 with bold rectangles, which show the area of pore measurements.

meadows etc.

The porosity of all studied specimens was measured from the same area on the umbones (Fig. 3).

The shells of *P. globulare* from the following Czech and Slovak sites were selected for measurement of pores: adult individuals - loc. 5 (n = 1), loc. 6 (n = 3), loc. 7 (n = 12), loc. 13 (n = 11), loc. 14 (n = 14), loc. 16 (n = 2), loc. 17 (n = 13), loc. 18 (n = 20), loc. 19 (n = 1), loc. 20 (n = 16), loc. 21 (n = 2); juvenile individuals - loc. 17 (n = 8), loc. 18 (n = 1), loc. 19 (n = 2), loc. 20 (n = 12). In total, 95 adult and 23 juvenile specimens from 12 populations were studied. The list of the sites is given in Appendix (part A).

The porosity of *P. casertanum* was assessed from different types of habitats across the area under study. The shells of *P. casertanum* from the following Czech and Slovak sites were selected for measurement of pores: adult individuals - loc. 1 (n = 3), loc. 2 (n = 2), loc. 3 (n = 2), loc. 4 (n = 4), loc. 5 (n = 4), loc. 6 (n = 3), loc. 7 (n = 5), loc. 8 (n = 2), loc. 9 (n = 4), loc. 10 (n = 3), loc. 11 (n = 4), loc. 12 (n = 3), loc. 13 (n = 3), loc. 14 (n = 5); juvenile individuals - loc. 2 (n = 1), loc. 4 (n = 3), loc. 5 (n = 4), loc. 7 (n = 3), loc. 9 (n = 1), loc. 11 (n = 3), loc. 12 (n = 2), loc. 13 (n = 2), loc. 14 (n = 4). In total, 47 adult and 23 juvenile specimens from 14 populations were studied. The list of the sites is given in Appendix (part B).

Altogether, 46 adult specimens of *P. globulare* from 10 sites were measured (length, height, width). Inflatedness was then calculate as  $100 \times \text{width} / \text{height}$ .

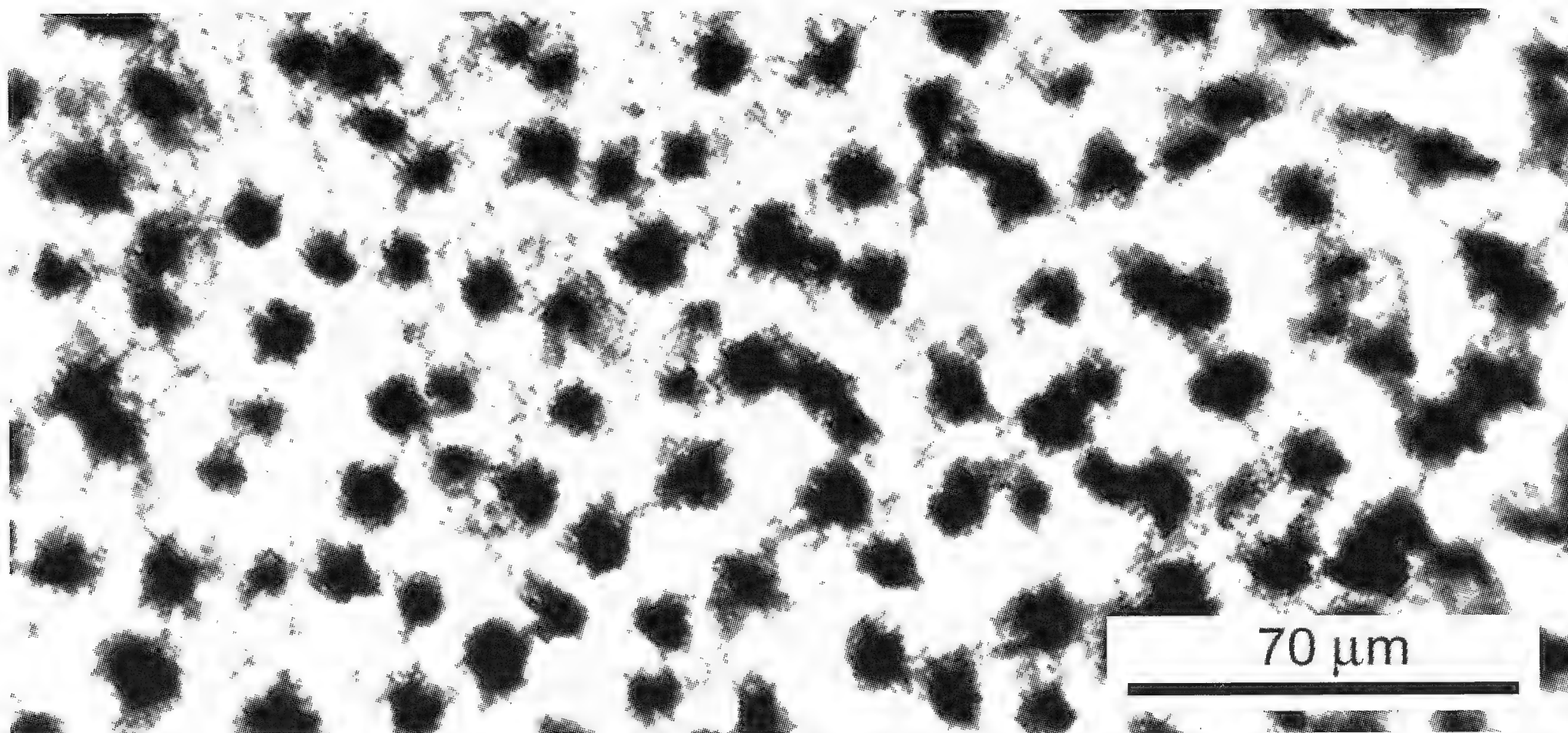
All measurements were made using an Olympus BX 50 microscope and Lucia Image digital picture analysis software at the Department of Zoology and Ecology, Faculty of Science, Masaryk University Brno.

The variability of measured characters is shown by Box & Whisker Plots. The significance of different porosity was assessed on the basis of non-parametric Mann-Whitney test. A level  $\alpha = 0.05$  was taken as a crucial limit for rejecting tested hypotheses.

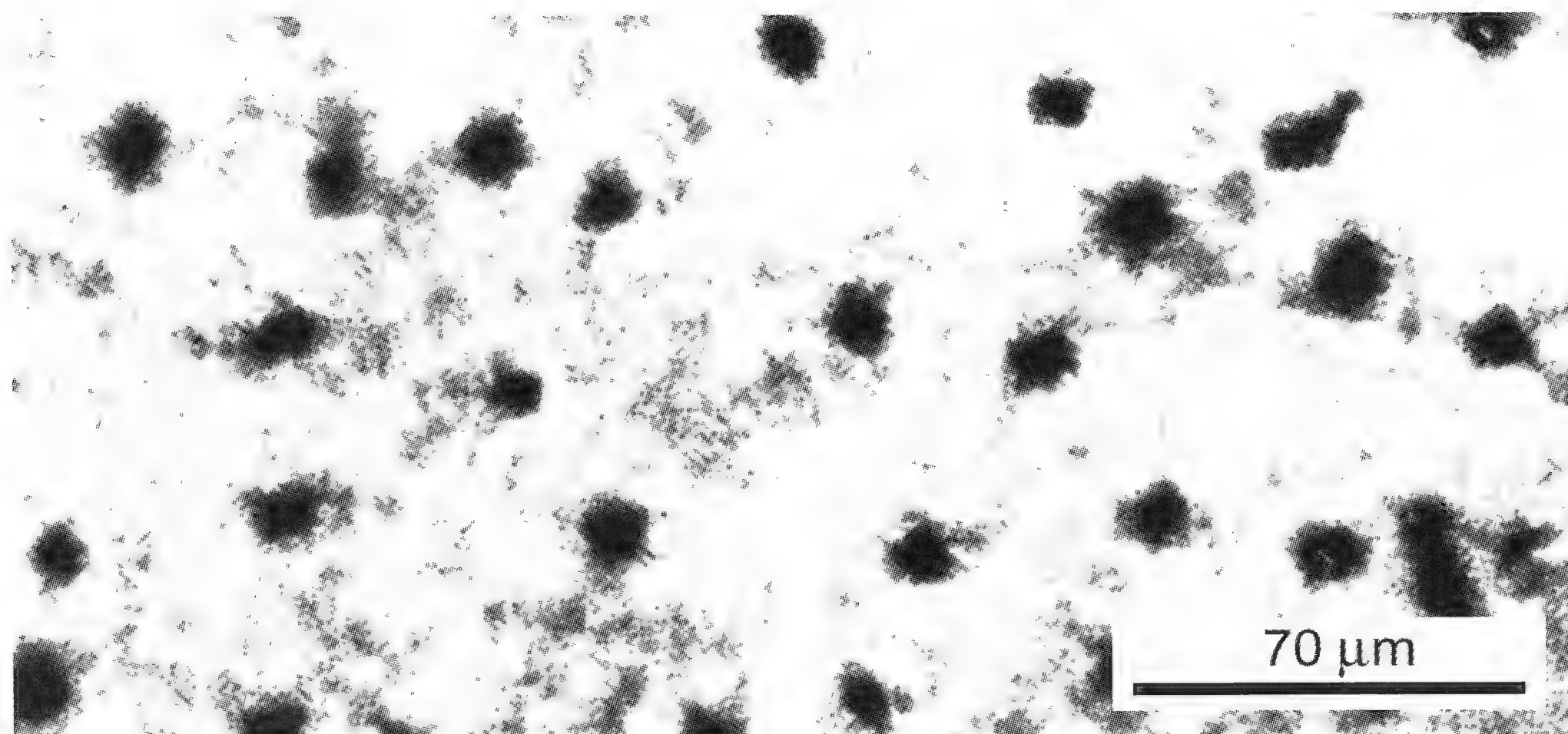
## RESULTS

In the course of revision 19 records of *P. globulare* from the Czech Republic (18 sites) and 2 records from the one site in Slovakia were found (Appendix and Fig. 1). In all cases *P. globulare* was collected in wetland habitats of big lowland river alluviums. Mostly





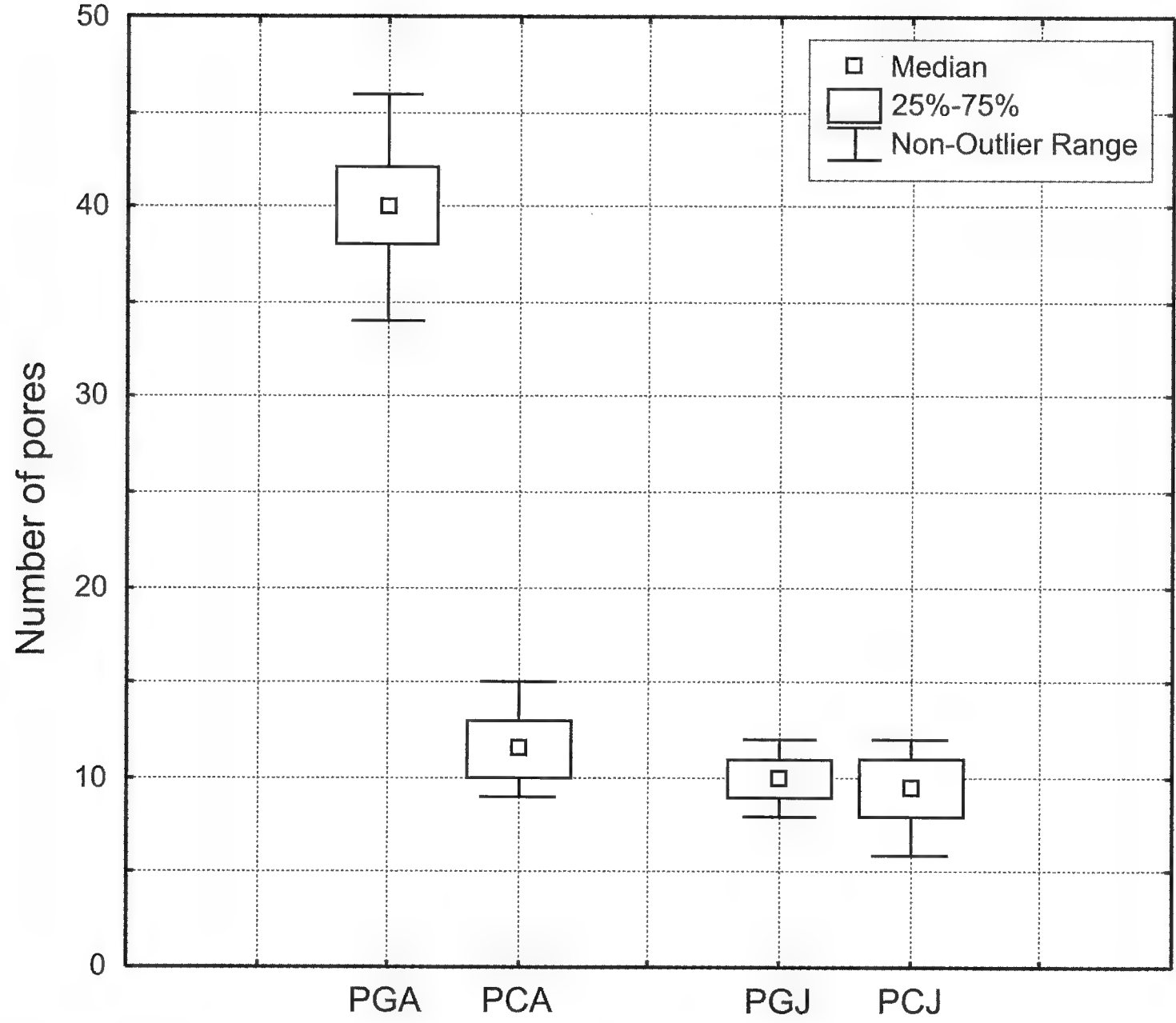
**Figure 4** Pore density of grown *Pisidium globulare* Clessin, 1873



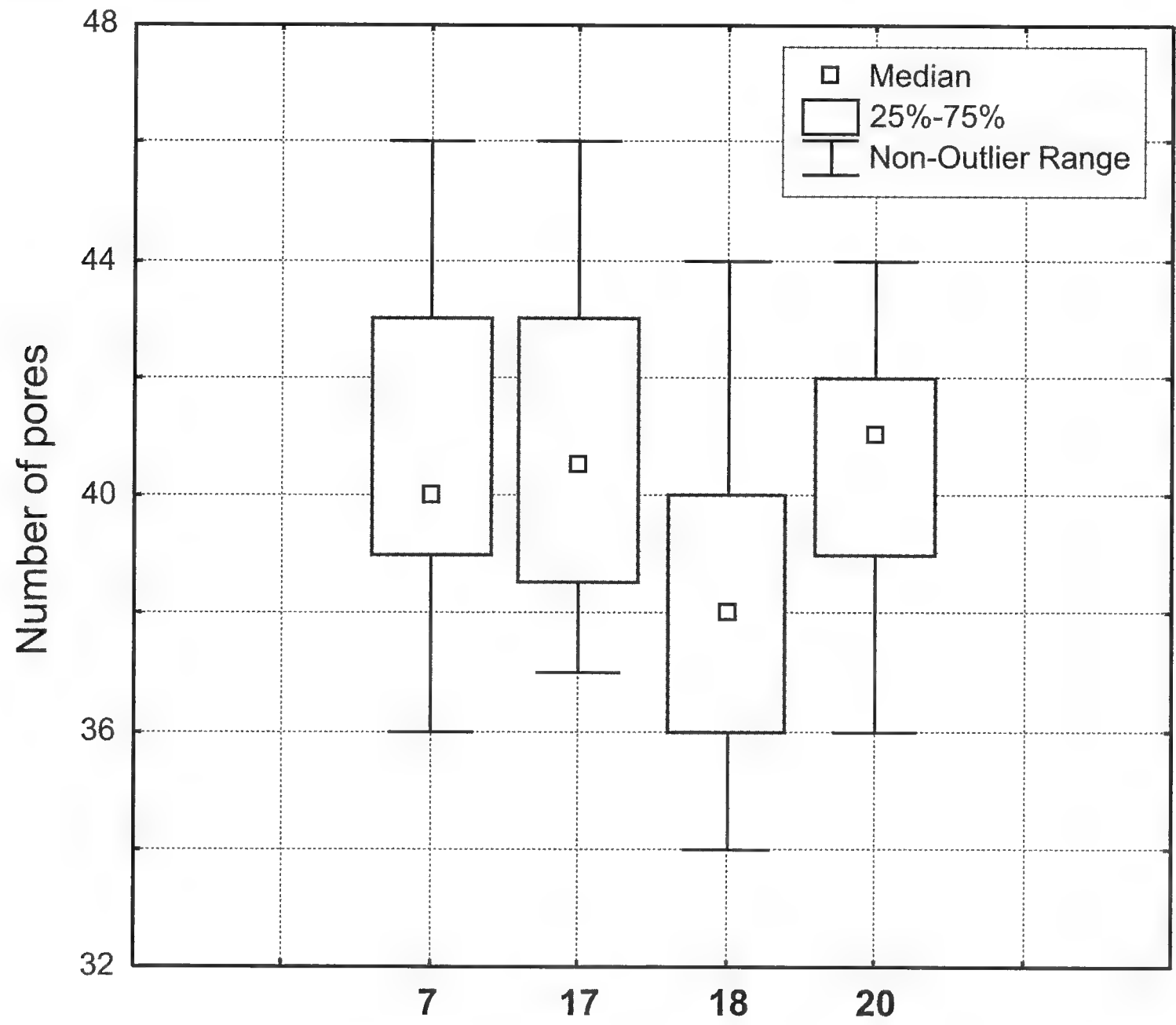
**Figure 5** Pore density of grown *Pisidium casertanum* Poli, 1791

these were shallow, open small pools or meadow swamps with very rich malacofauna (sometimes more than 20 species). These sites are naturally rich in trophic value, which causes shortage of oxygen supply. Only in five sites *P. globulare* and *P. casertanum* were encountered together, but without any mixed form (in most cases *P. casertanum* was more abundant).

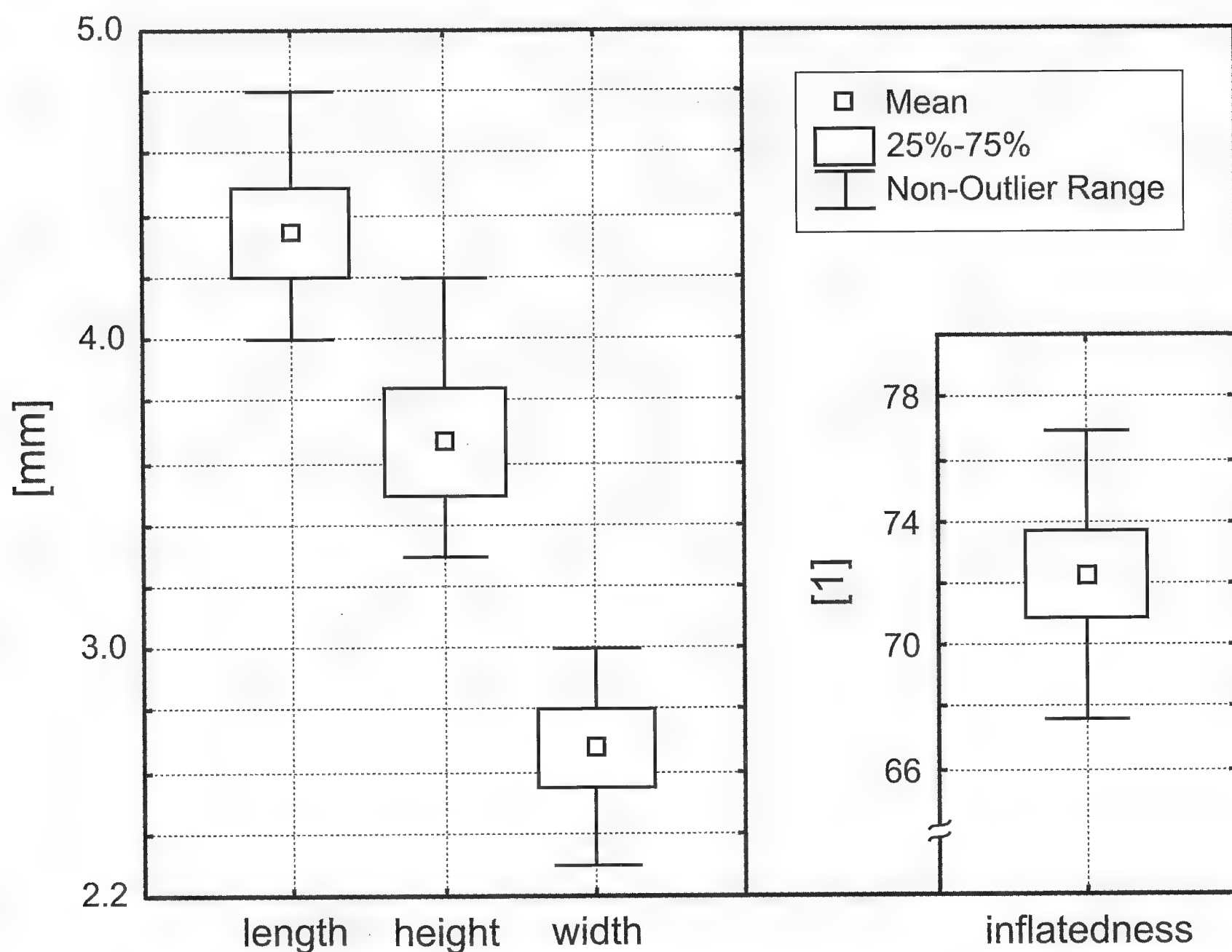
Measurement of pore density revealed significant differences between adult individuals of the compared species ( $P = 0.016$ , Mann-Whitney test; cf. Figs 4 and 5, see Fig. 6). The porosity of *P. globulare* varied from 34 to 46 pores per  $0.02 \text{ mm}^2$  with median value of 40 pores. The range within particular populations was similar (Fig. 7). In contrast, the porosity of *P. casertanum* varied from 9 to 15 pores per  $0.02 \text{ mm}^2$  with median value of 12 pores. Very interesting data were obtained from measurements of juvenile specimens. The porosity of juvenile individuals of both species was without significant differences ( $P = 0.57$ , Mann-Whitney test; Fig. 6). There are different patterns in development of porosity of both species. During the growth the porosity significantly increases (*P. globulare*) or it remains approximately the same (*P. casertanum*) (Fig. 6).



**Figure 6** Heterogeneity of pore density in species examined. *Pisidium globulare* Clessin, 1873: PGA - adult specimens, PGJ - juvenile specimens. *Pisidium casertanum* Poli, 1791: PCA - adult specimens, PCJ - juvenile specimens.



**Figure 7** Variability of pore density of particular *Pisidium globulare* Clessin, 1873 populations. For the explanation of abbreviations see Material and methods.



**Figure 8** Variability of shell measurements of grown *Pisidium globulare* Clessin, 1873.

The adult shell proportions of *P. globulare* (length, height, width, and inflatedness) are shown in Figure 8.

## DISCUSSION

*P. globulare* used to be synonymized with *P. casertanum* for a long time. Firstly Korniuschin (1998) pointed out peculiar characters, which indicated the species value of *P. globulare*. This was confirmed by Korniuschin (1999) and Korniuschin and Hackenberg (2000). By Czechoslovak authors *P. globulare* was often labelled as *P. casertanum* f. *ovatum* (Clessin, 1877) and probably also as *P. casertanum* f. *roseum* (Scholtz, 1843), which is shown especially by Brabenec (1973). Unfortunately, it is not possible to adapt records of these two above-mentioned forms as *P. globulare*. These data represent mostly records of *P. casertanum* specimens with a more globular shell, which come from peat bog waters as revealed by the revision of Czechoslovak voucher material. The similarity of *P. globulare* with *P. roseum* Scholtz, 1843 was supposed by Stadnichenko (1984) and Korniuschin (1995), but their view was revealed as erroneous (Korniuschin, 1998). *P. roseum* in its original sense seems to be a form of *P. casertanum*. However, according to results of other authors *P. casertanum* f. *roseum* could be misidentified as *P. globulare* (note of anonymous reviewer).

The porosity of Czechoslovak populations of *P. globulare* is similar to the porosity of populations from Ukraine and Russia. The results of measurements are in very good accordance with the results presented by Araujo and Korniuschin (1998). They usually mentioned lower numbers of pores in the case of young specimens, but their material was not sufficient for statistical treatment. Also other conchological characters of *P. globulare* such as globose shell (Fig. 2) and short lateral teeth were visible on Czechoslovak



material. However, these characters cannot be used for reliable identification due to their overlap considering the high variability of *P. casertanum*.

*P. globulare* is considered a typical inhabitant of different types of wetlands (Korniushin, 1998; Korniushin, Janovich and Melnichenko, 2002; Greeke and Kalnins, 2002; Glöer and Meier-Brook, 2003). Mainly these are swamps, wet meadows, forest pools, littoral zone of small ponds, and lakes. Also in the Czech Republic and Slovakia *P. globulare* lives only in wetlands. It was found in swamps, as well as in open and forest pools of big lowland rivers alluviums. These habitats are often semi-periodic, shallow, and naturally rich in trophy. In the Czech Republic and Slovakia *P. globulare* has never been encountered either in acidic or oligotrophic wetlands of higher altitudes. It seems to be a rare species inhabiting natural wetlands with no or low human impact. *P. globulare* is probably also an endangered species. Regulations of lowland rivers and influences of agriculture caused degradation or destruction of most of its habitats.

### ACKNOWLEDGEMENTS

This research project was supported by the grant of the Grant Agency of the Czech Republic No. 206/02/0568, by the grant of the Ministry of Culture of the Czech Republic No. RK01P03OMG004, and by the grant of the Ministry of Education No. MSM 143100010. We wish to thank J. Schlaghamerský for help with the English and anonymous reviewer for valuable comments on the first version of the manuscript.

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## APPENDIX

Survey of all known sites of *P. globulare* in the Czech Republic and Slovakia (part A) and localization of studied population of *P. casertanum* (part B).

Data in the list are as follows: number of the site (bold), geographical co-ordinates (N, E) (Geobáze digital map of the Czech Republic 1:100,000), country (CZ - Czech Republic, SK - Slovakia), code of the mapping grid for faunistic mapping according to Pruner & Míka (1996) or databank of Fauna Slovakia, description of the site, elevation (m a.s.l., approximately), date of investigation, name of investigator, number of specimens (ex.). The sites are listed according to date of investigation.

### Part A - *Pisidium globulare*

**1** - 50°05'37", 15°42'10", CZ, 5960, a swamp in the vicinity of the road to Hradec Králové (Lázně Bohdaneč town), 220 m, viii. 1939, A. Culek, 38 ex.; **2** - 50°04'37", 15°41'45", CZ, 5960, wet meadows below Rozkoš (Lázně Bohdaneč town), 220 m, viii. 1939, A. Culek, 45 ex.; **3** - 50°02'05", 15°48'59", CZ, 5960, Studánka - part of Pardubice town, 230 m, 5. ix. 1944, J. Brabenec, 16 ex.; **4** - 49°54'02", 17°33'50", CZ, 6071, a swamp near Moravice river near Leskovec nad Moravicí village (now flooded by Slezská Harta reservoir), 500 m, 23.vii. 1953, J. Brabenec, 11 ex.; **5** - 49°47'51", 18°11'58", CZ, 6275, a swamp between railway tracks north-east of Přemyšov village near Polanka, 215 m, 17. v. 1953, S. Mácha, 2 ex.; **6** - 49°51'24", 18°21'53", CZ, 6176, small ponds north of Podlesí (Rychvald town), 215 m, 14. x. 1954, S. Mácha, 33 ex.; **7** - 48°38', 21°28', SK, 7394, a swamp 300 m west of Slanec castle ruin near Košice town, 420 m, 20. viii. 1956, S. Mácha, 108 ex.; **8** - 50°05'34", 15°40'23", CZ, 5960, Bohdanečský rybník a rybník Matka National Nature Reserve near Lázně Bohdaneč town, 220 m, 8. vii. 1956, J. Brabenec, 24 ex.; **9** - 49°48'56", 18°30'46", CZ, 6177, Stonava village near Ostrava, 250 m, 12. viii. 1957, J. Brabenec, 139 ex.; **10** - 50°17'01", 14°30'36", CZ, 5753, Černínovsko National Nature Reserve near Libiš town,

160 m, 20. ix. 1959, J. Brabenec, 23 ex.; **11** - 50°05'33", 15°10'16", CZ, 5957, wetlands in the vicinity of Velký Osek village, 190 m, 14. v. 1961, J. Brabenec, 10 ex.; **12** - 50°24'08", 16°04'31", CZ, 5562/5662, a small temporary pool in the eastern part of Dubno Nature Reserve near Česká Skalice town, 290 m, 15. iv. 1963, J. Brabenec, 86 ex.; **13** - 50°24'10", 16°04'18", CZ, 5562/5662, Dubno Nature Reserve near Česká Skalice town, 300 m, 15. iv. 1963, J. Brabenec, 170 ex.; **14** - 48°38', 21°28', SK, 7394, a swamp 300 m west of Slanec castle ruin near Košice town, 420 m, 7. ix. 1963, J. Brabenec, 200 ex.; **15** - 50°02'19", 15°44'57", CZ, 5960, ponds behind the distillery in the north-western part of Pardubice town, 220 m, 8. x. 1963, J. Brabenec, 64 ex.; **16** - 49°46'58", 18°23'06", CZ, 6276, a wet meadow near Lučina river (south-east of Šenov village), 235 m, 6. xiii. 1968, S. Mácha, 2 ex.; **17** - 49°43'37", 18°06'54", CZ, 6274, a shallow meadow canal north of Bažantula floodplain forest near Studénka village, 225 m, 29. v. 1979, S. Mácha, 205 ex.; **18** - 49°46'49", 18°22'20", CZ, 6276, a swamp north-east of Volenský pond (near Šenov village), 235 m, 10. xiii. 1983, S. Mácha, 79 ex.; **19** - 49°42'21", 18°04'57", CZ, 6274, a meadow pool near north-western margin of Kačák pond (near Studénka village), 230 m, 3. ix. 1999, M. Horsák, 34 ex. (orig. published as *P. casertanum* (Horsák 2000)); **20** - 49°42'18", 18°04'43", CZ, 6274, a meadow pool near north-eastern bank of Kotvice pond (near Studénka village), 230 m, 3. ix. 1999, M. Horsák, 150 ex. (orig. published as *P. casertanum* (Horsák 2000)); **21** - 48°45'45", 17°01'50", CZ, 7268, a forest shallow oxbow lake 1 km north of Rýnava (near Tvrdonice village), 157 m, 4. x. 2001, M. Horsák, 45 ex.

#### Part B - *Pisidium casertanum*

**1** - 49°47'51", 18°11'58", CZ, 6275, a swamp between railway tracks north-east of Přemyšov village near Polanka, 215 m, 17. v. 1953, S. Mácha, 75 ex.; **2** - 48°59'25", 17°54'23", CZ, 7073, Hutě Nature Reserve - a calcareous spring fen, 500 m, 20. v. 2000, M. Horsák, 139 ex.; **3** - 49°01'09", 17°48'43", CZ, 6972, a small pond 2 km south of Bojkovice town, 290 m, 9. vi. 2000, M. Horsák, 37 ex.; **4** - 49°53'14", 13°52'52", CZ, 6672, a rich Sphagnum-fen 1.23 km north of Košovy settlement (near Rajnochovice village), 445 m, 27. ix. 2000, M. Horsák, 714 ex.; **5** - 49°19'26", 17°53'03", CZ, 6673, Pivovařiska Nature Monument near Hošťálková village (a wet-meadow), 475 m, 27. ix. 2000, M. Horsák, 126 ex.; **6** - 49°47'48", 14°55'24", CZ, 6255, a pond south-east of Šternov village, 400 m, 5. v. 2001, M. Horsák, 32 ex.; **7** - 49°37'27", 14°52'11", CZ, 6355, Podlesí Nature Reserve near Louňovice pod Blaníkem Village (a small swamps), 480 m, 6. v. 2001, M. Horsák, 125 ex.; **8** - 49°18'31", 15°45'33", CZ, 6660, a small brook north-east of Bransouze village, 460 m, 29. v. 2001, M. Horsák, 26 ex.; **9** - 50°18'01", 17°41'39", CZ, 5772, Velký Pavlovický pond Nature Reserve near Slezské Pavlovice village (influx of the pond), 215 m, 6. viii. 2001, M. Horsák, 44 ex.; **10** - 50°18'01", 17°41'39", CZ, 5772, Velký Pavlovický pond Nature Reserve near Slezské Pavlovice village (small pools), 215 m, 6. viii. 2001, M. Horsák, 15 ex.; **11** - 49°11'36", 19°31'20", SK, 6883, a calcareous spring fen near Borinka brook south of the Velké Borové village, 840 m, 19. vi. 2002, M. Horsák, 83 ex.; **12** - 49°38'54", 18°25'32", CZ, 6376, Bahno - a small brook near Skalice village, 350 m, 3. vii. 2002, M. Horsák, 29 ex.; **13** - 48°56'51", 18°29'08", SK, 7076, Hanušová - a brown moss rich fen near Zliechov village, 725 m, 24. viii. 2002, M. Horsák, 115 ex.; **14** - 50°39'05", 14°37'49", CZ, 5353, Ploučnice river near Brenná village, 270 m, 19. ix. 2002, M. Horsák, 303 ex.





# CONTRIBUTION TO THE KNOWLEDGE OF THE TERRESTRIAL MALACOFaUNA OF THE ISLAND GROUP OF DIONYSADES (CRETE, GREECE)

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*Abstract* Dionysades is a group of four isolated islets close to the NE coasts of Crete. Among the 22 species of land snails that were found on the four islets 19 have living populations while 6 are reported for the first time. The synthesis of the malacofauna of the whole island group is in agreement with the paleogeographic history of the region and it appears to be relictual compared to the malacofauna of eastern Crete.

*Key words* Land snails, endemism, satellite islets, Dionysades, Crete, biogeography.

## INTRODUCTION

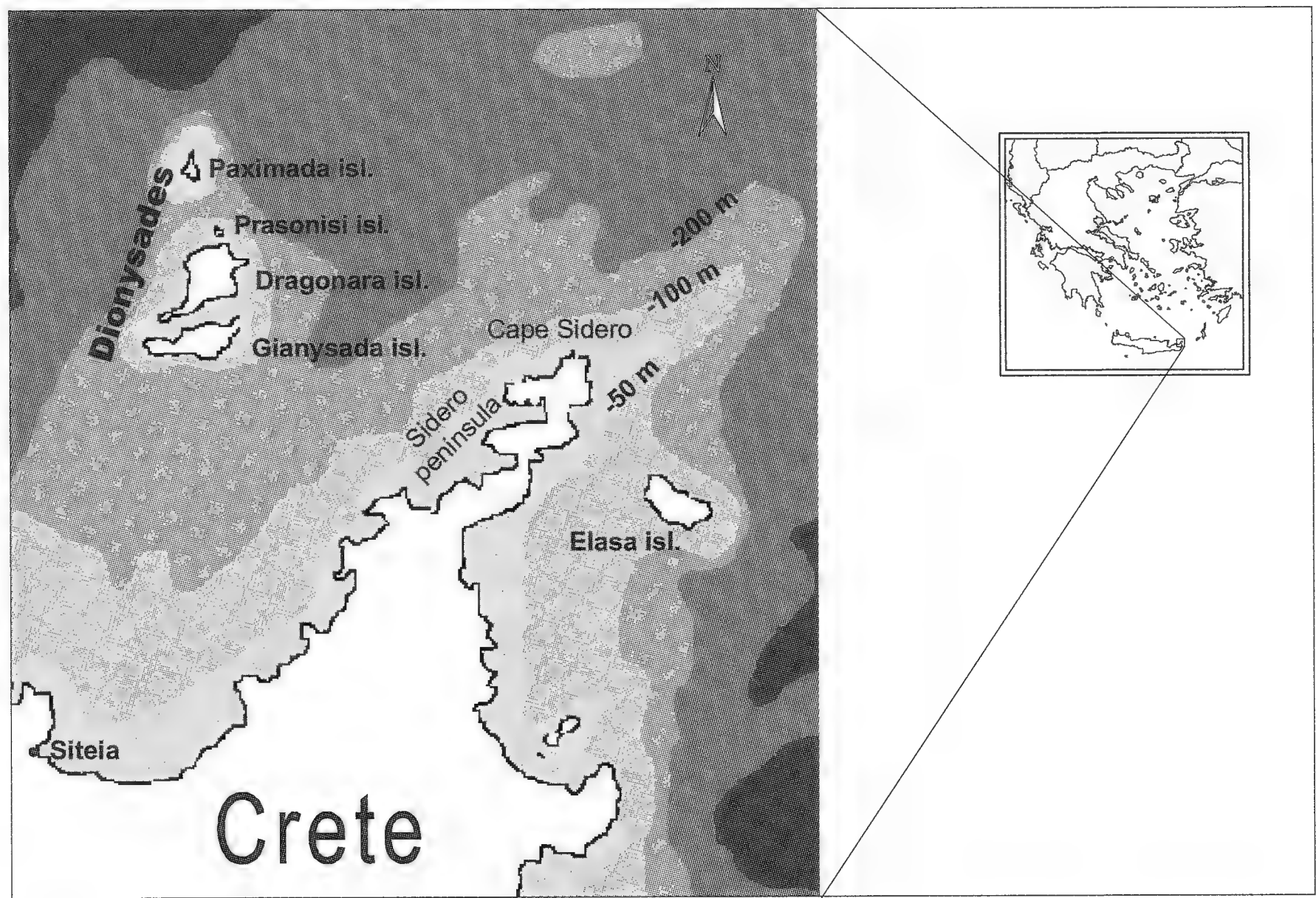
Dionysades is a group of four uninhabited islets off the northeast coast of Crete. They are well known to scientists, especially ornithologists, because they consist one of the major breeding places of *Falco eleonora* G  n  , 1839 (Aves). This is the main reason that all the islets are under special protection status. Dionysades islets are found 11.7 km northwest of cape Sidero at the easternmost end of Crete (Fig. 1). The largest, Dragonara islet, is 2.84 km<sup>2</sup> while the smallest, Prasonisi isl., reaches 0.034 km<sup>2</sup> (Table 1). All four islets consist of limestone (Varnavas, 1988) and they all have steep cliffs. Also, on Dragonara isl. Pleistocene sandstone deposits are present (Fassoulas pers. obs.). Climatic data are available only from the opposite coast of Crete, in particular for Siteia, with mean annual rainfall of 474 mm and mean annual temperature of 19  C (Pennas, 1977). The climate of the area is characterized as thermomediterranean (Mavromatis, 1978) with a long dry period, from end of April to early October. The vegetation on the three islets consists mainly of phrygana, the dominant plants being *Euphorbia dendroides* (L.) and *Coridothymus capitatus* (L.) Reichenb.fil. Their coastal area is dominated by halophytes (Christodoulakis, Georgiadis, Economidou, Iatrou & Tzanoudakis, 1990). On Dragonara an extensive formation of maquis with *Juniperus phoenicea* L. is present, while on the southernmost islet, Gianysada, there are only some degraded patches. The smallest islet, Prasonisi, is totally covered by halophytes (pers. obs.).

In 1942 Rechinger, Wettstein and Werner surveyed the islands and islets of Greece and collected both plant and animal material; they also collected from Dionysades. Loosjes (1955) based on that material published a paper concerning the clausiliids of Crete. From Dionysades, apart from the presence of *Albinaria teres* var. *extensa* he described three new subspecies: *Albinaria vermiculata janisadana* Loosjes, 1955, *Albinaria vermiculata dragonarana* Loosjes, 1955 and *Albinaria vermiculata paximadiana* Loosjes, 1955. Four decades later Welter-Schultes studying clausiliids on Crete resurveyed these islets and in Schultes & Wiese (1991) his results were published and a new clausiliid species from Gianysada, *Albinaria janicollis* Schultes & Wiese, 1991 was described. Also, they gave a list of the other taxa present on the islets and data concerning the smallest islet, Prasonisi, were presented for the first time. Welter-Schultes (1998) in an extended study of the terrestrial molluscs of Gavdos island, presented again a revised list of the terrestrial molluscs of Dionysades islets with many differences from the previous one.

In this paper based on a rich material collected by the authors at the end of the most

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**Fig. 1** Map showing the study area, its relative position to the northeastern part of the island of Crete and the 50, 100 and 200 m isobaths.

favourable period of the year for sampling land snails in the region (Vardinoyannis, 1994), we complement the malacofauna of the islet group and discuss its relation with the malacofauna of Crete and its eastern satellite islets.

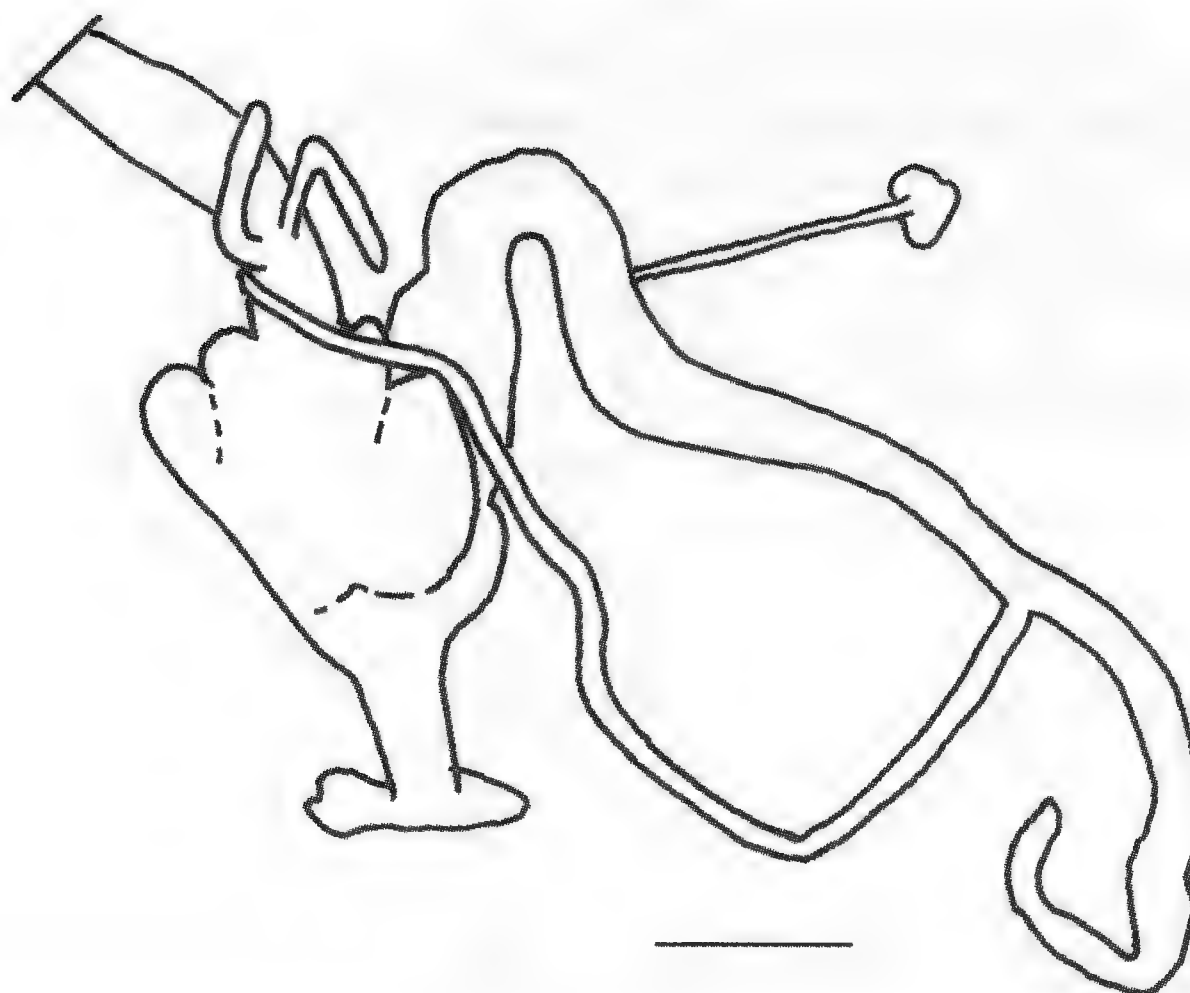
MATERIALS AND METHODS

We visited the island group of Dionysades during April of 1999 and collected land snails from all four islets. We sampled all the different habitats present on each islet, and

TABLE 1  
Area and altitude of the four islets of Dionysades group.

Islet	Area (km <sup>2</sup> )	Altitude (m)
Paximada	0.3	133
Prasonisi	0.034	44
Dragonara	2.84	128
Gianysada	2.080	147





**Fig. 2** Anatomy of the terminal genitalia of *Pseudoxerophila* aff. *gradilis* from Paximada islet; scale bar 1 mm.

collected litter and soil under different plants.

The collected specimens were drowned in water for 24 hours and then preserved in 75% alcohol. Some of the individuals were preserved in 100% alcohol for future molecular approach. In the laboratory, the collected litter was sieved, through 5 - 0.4 mm mesh size, and examined under a magnifying lens.

In the manuscript, we followed the conversion of Greek characters according to the Hellenic Organization for Standardization.

The authors identified all species. All the material collected is held in the Natural History Museum of Crete.

## RESULTS

In total 22 species have been found on Dionysades islet group (Table 2). One of these species, *Helix nucula*, was found as fossil, while two others, *Theba pisana* and *Helix aspersa* are represented only as empty shells. Thus, 19 species of land snails seem to have living populations on the islets. On Dragonara, the largest islet, 14 species have been observed, while only 12 are living on the islet; 6 species are new records for the islet. On the southern islet, Gianysada, 15 species are present, including 4 new records for the islet; while on the northern islet, Paximada, there are 11 species with 6 of them being new records. On the smallest islet, Prasonisi, 10 species have been found, 8 of them have living populations, and one of the species is new record for the islet.

From the 22 species found, 6 are reported for the first time from this island group: *Orculella critica*, *Deroceras lasithionensis*, *Pseudoxerophila bathytera*, *Metafruticicola noverca*, *M. pellita* and *Helix nucula* (Table 2). Sixteen of these species are distributed in the lowland of eastern Crete, while 2 species are found on Crete, but further westwards. One species, *Mastus* sp., has not yet a clear taxonomic position. The only endemic species of this island group are two species of the genus *Albinaria*, *A. janicollis* and *A. janisadana*.

TABLE 2

Species found on the four islets and their presence on the nearby coasts of Crete or Crete in general. N: new record for the island; +: present on the islet (based on literature and our observations); -: absent from the islet; B: bibliographic data only. Brackets are used for non - living species. Data for Crete are from Vardinoyannis (1994) and from the collections of the Natural History Museum of Crete.

Species	Gianysada	Dragonara	Prasonisi	Paximada	Opposite coast	Present on Crete
1. <i>Orculella critica</i> (Pfeiffer, 1856)	N	N	-	N	+	+
2. <i>Cecilioides tumulorum</i> (Bourguignat, 1856)	N	N	B	+	+	+
3. <i>Cecilioides acicula</i> (Müller, 1774)	-	+	-	-	+	+
4. <i>Rumina decollata</i> (Linnaeus, 1758)	+	+	+	N	+	+
5. <i>Pleurodiscus sudensis</i> (Pfeiffer, 1846)	+	-	-	-	-	+
6. <i>Granopupa granum</i> (Draparnaud, 1801)	+	+	-	-	+	+
7. <i>Mastus</i> sp.	+	+	+	+	-	-
8. <i>Albinaria janicollis</i> Schultes & Wiese, 1991	+	-	-	-	-	-
9. <i>Albinaria janisadana</i> Loosjes, 1955	+	+	+	+	-	-
10. <i>Deroceras lasithionensis</i> Wiktor, Vardinoyannis & Mylonas, 1992	N	-	-	-	+	+
11. <i>Vitrea contracta</i> (Westerlund, 1871)	+	-	-	-	+	+
12. <i>Lindbergia pseudoillyrica</i> Riedel, 1960	B	N	-	B	+	+
13. <i>Oxychilus aegopinoides</i> (Maltzan, 1883)	+	+	+	-	+	+
14. <i>Trochoidea cretica</i> (Férussac, 1821)	+	+	+	N	+	+
15. <i>Pseudoxerophila bathytera</i> (Blanc, 1879)	-	-	-	N	+	+
16. <i>Pseudoxerophila</i> aff. <i>gradilis</i>	-	-	-	N	-	-
17. <i>Metafruticicola noverca</i> (Pfeiffer, 1853)	-	N	-	-	+	+
18. <i>Metafruticicola pellita</i> (Férussac, 1832)	N	-	N	N	+	+
19. <i>Eobania vermiculata</i> (Müller, 1774)	+	+	+	+	+	+
<i>Helix nucula</i> Pfeiffer, 1859	-	(N)	-	-	-	+
<i>Theba pisana</i> (Müller, 1774)	-	-	(B)	-	+	+
<i>Helix aspersa</i> Müller, 1774	-	(N)	(+)	-	+	+
Total number of species	15	12+(2)	8+(2)	11	16	18

REMARKS ON THE SPECIES FOUND

*Pleurodiscus sudensis*

*Pleurodiscus sudensis* is an endemic species of central Crete (Vardinoyannis, 1994) and its presence on Gianysada appears to be out of its main range. Also Gianysada is the only satellite islet of Crete that this species has been found. It lives in limestone areas with rich terra rossa soil, and hides deep in the soil (Bar 1974, Vardinoyannis pers. obs.) and for this reason it is difficult to find alive specimens. We believe that though we did not find any live individuals, but only fresh shells, the species, most probably, has a living population on the islet.

*Mastus* sp.

The most abundant species on all the islets of Dionysades is one species belonging to the genus *Mastus*. Schultes & Wiese (1991) named this species *M. cretensis*, while Welter-Schultes (1998) did not name it. In 2000 the same author (Welter - Schultes, 2000) named it again as *M. cretensis* but he also wrote that it could represent an endemic species due to its larger shell dimensions. Parmakelis (2003), based on the morphology of the genitalia and the spermatophore of the specimens that we had collected from the four islets, concluded that the species could be named as *M. hemmeni* sensu Maassen (1995). However, based on molecular data (16S rRNA, mtDNA gene) he concluded that it might be an endemic taxon of this island group. The above contradictory data do not allow us to give a specific name to the populations of *Mastus* from Dionysades in the present study.

It is worth noting that on Prasonisi *Mastus* sp. presents an extremely dense population; more than 15-20 individuals were found under almost every stone or under plants of *Allium* sp.

*Oxychilus aegopinoides*

This species is a large zonitid, endemic of the easternmost part of the island of Crete. On Crete it is quite rare, with living populations in Cape Sidero and on a plateau close the village Kato Zakros (Riedel, 1990), but on Dionysades, and especially on Dragonara islet, dense populations are found. The species was found under large stones, stuck on them, or under piles of large stones.

*Trochoidea cretica*

*T. cretica* is a species characteristic of the lowland vegetation (phrygana, maquis and cultivations) of central and south Aegean islands (Mylonas, 1982; Vardinoyannis, 1994). The species has a variable shell, even within a population, but its terminal genitalia are quite constant. The classification of this species, as in most Hygromiidae, is impossible even at the generic level, without anatomy.

Schultes & Wiese (1991), based only on shell morphology, recorded *T. cretica* from Dragonara, Gianysada and Prasonisi; a second Hygromiid, unidentified *Trochoidea* spec., was reported from Dragonara, Prasonisi and Paximada. Welter-Schultes (1998) working on the same material of his previous study, changed the taxonomic results and reported *T. cretica* and *Pseudoxerophila* spec. but not *Trochoidea* spec.

We identified, based on shell morphology as well as the reproductive system, *T. cretica* on every islet and two species of *Pseudoxerophila* from Paximada.

*Pseudoxerophila bathytera* and *P.aff. gradilis*

*P. bathytera* is a common species in the lowland areas of eastern and central Crete and the adjacent islets (Vardinoyannis, 1994). Without anatomy it is easy to misidentify this species, even at the generic level; it can be easily identified as *Helicopsis* or *Helicella* or any taxon of Hygromiidae with a wide umbilicus and a flat shell.

On Paximada we also found the congeneric *Pseudoxerophila* aff. *gradilis*, which has a quite different shell and terminal genitalia (Fig. 2) from *P. bathytera*. The shell is very similar with *Helix* (*Xerophila*) *gradilis* described by Martens (1889) and presented in taf. 10, fig. 12.

*Metafruticicola* spp.

Schultes & Wiese (1991) mentioned that two species or subspecies of *Metafruticicola* are distributed on Dionysades, but they did not give any specific names.

On Dragonada islet we found only *Metafruticicola noverca*, a common endemic species all over the island of Crete, while on the other three islets *M. pellita* is present, which is distributed in many Aegean islands but only in the eastern part of Crete.



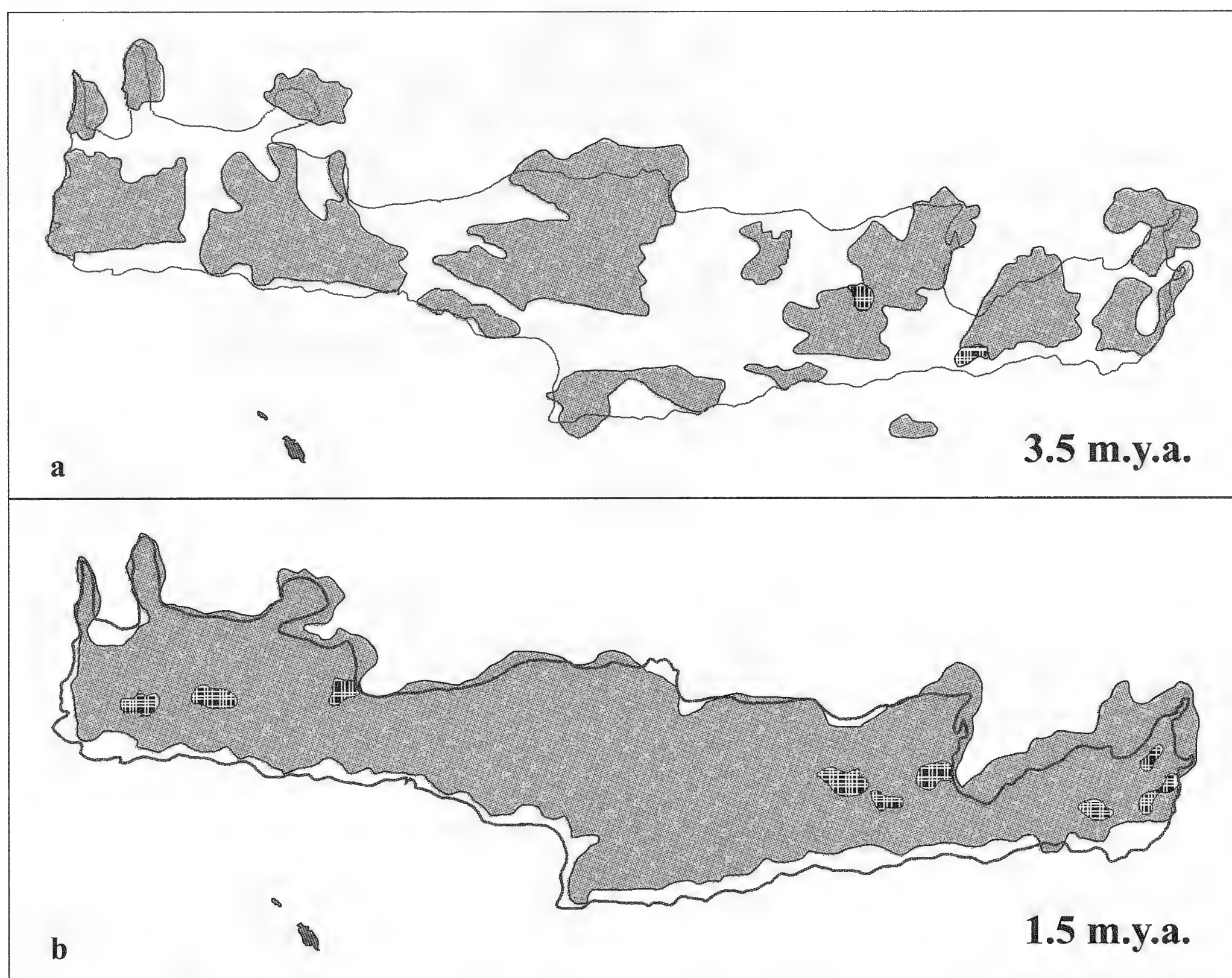


Fig. 3 Paleogeographic sketch of Crete during (a) Pliocene and (b) Pleistocene.

■ land, ▨ lake, □ sea. (redrawn from Dermitzakis, 1990).

#### Shells of *Helix aspersa* and *Theba pisana*

On the islets of Dragonara and Paximada we found recent empty shells of *Helix aspersa*. It is our strong belief that seagulls transported from Crete the shells on the islets, since near their resting sites or nests shells are found among other food remains such as olive seeds, bones and limpets. Thus, *Helix aspersa*, cannot be included in the extant malacofauna of the islets. Often this species is included in the malacofauna of the islets of the Aegean, based on the presence of few shells, but this is erroneous since this species has never been found alive on very small islands of the central and south Aegean (Mylonas pers. obs.).

Shells of *Theba pisana*, which is a common snail of sandy coastal and cultivated areas in Crete and in other Aegean islands, have been reported from Prasonisi islet (Schultes & Wiese, 1991). We believe, as in the case of *H. aspersa*, that these shells have also been transported on the islet by birds, thus *Theba pisana* cannot be included in the living malacofauna of the islets.

#### *Helix nucula*

*Helix nucula* was found as fossil in the sandstone deposits of Dragonara isl. This species has a disjunct distribution in Greece; it is found extant only on certain sandy coastal areas of Crete (Vardinoyannis, 1994; Welter-Schultes & Wiese, 1997a) and on Anafi isl. (Cyclades) (Mylonas, 1982). Except from Crete and its satellite islets, we have

found this species as fossil on Armathia islet (north of Kasos, Dodekanisa) (collection of Natural History Museum of Crete).

DISCUSSION

In 1991 Schultes & Wiese reported from Dionysades 18 taxa. Four of them were classified only at the generic level - *Orculella*, *Metafruticicola*, *Trochoidea* spp. Some years later Welter - Schultes (1998) added one more species, *Cecilioides acicula*, and replaced *Trochoidea* sp. by *Pseudoxerophila* sp. In the present paper we identified all samplings at species level except of two cases. Taxonomic characters for *Mastus* are contradictory, whereas for *Pseudoxerophila* aff. *gradilis* it is necessary to compare our samples with specimens from the nearby island of Elasa, which is the locus typicus of *Helix* (*Xerophila*) *gradilis* (Martens, 1889).

As a result of our work the malacofauna of Dionysades comprises 19 extant taxa, one extinct and two species by “transported” empty shells (Table 2).

The species number on each islet is higher compared to those given by Welter – Schultes & Williams (1999) except in the case of Prasonisi islet where it is the same.

Among the extant taxa 8 species (42%) are present on only one islet, while 6 species are present on all islets. The synthesis of the malacofauna is different on each islet (Table 2), but this is not surprising since these differences occur also among sites on Crete (Cameron, R.A.D., Mylonas, M., Vardinoyannis, K. 2000). As far as endemic species are concerned there are 2 strict endemic species, both belonging to the genus *Albinaria*, one found on all four islets while the other only on the southern island. Also there are 4 species endemic of Crete and its satellite islands, while 3 are endemic of the Aegean islands (Table 3). Moreover, 8 species present a wide distribution either Mediterranean (6 species) or Palearctic (2 species) (Table 3).

TABLE 3

Element of the land snails in Dionysades. **PAL**: Palaearctic element. **MED**: Mediterranean element, **AEG**: Aegean endemic, **ENDcr**: endemic of Crete and/or its surrounding islets, **ENDdio**: endemic of Dionysades group.

1.	<i>Orculella critica</i>	MED
2.	<i>Cecilioides tumulorum</i>	MED
3.	<i>Cecilioides acicula</i>	PAL
4.	<i>Rumina decollata</i>	MED
5.	<i>Pleurodiscus sudensis</i>	ENDcr
6.	<i>Granopupa granum</i>	MED
7.	<i>Mastus</i> sp.	-
8.	<i>Albinaria janicollis</i>	ENDdio
9.	<i>Albinaria janisadana</i>	ENDdio
10.	<i>Deroceras lasithionensis</i>	AEG
11.	<i>Vitrea contracta</i>	PAL
12.	<i>Lindbergia pseudoillyrica</i>	ENDcr
13.	<i>Oxychilus aegopinoides</i>	ENDcr
14.	<i>Trochoidea cretica</i>	MED
15.	<i>Pseudoxerophila bathytera</i>	AEG
16.	<i>Pseudoxerophila</i> aff. <i>gradilis</i>	-
17.	<i>Metafruticicola noverca</i>	ENDcr
18.	<i>Metafruticicola pellita</i>	AEG
19.	<i>Eobania vermiculata</i>	MED

The presence of fossil *Helix nucula* on Dragonara isl. and in other Aegean islands [Gavdos isl. (dated  $17,000 \pm 1000$  years ago) (Vardinoyannis, 1994), Armathia islet (Dodekanisa, north of Kasos isl.)] indicates that this species is indigenous and had, in the past, a broader distribution in the Aegean area and it is not human dispersed from North Africa as Welter-Schultes & Wiese (1997b) support.

The palaeogeographic history of the area shows that the whole group was part of eastern Crete until late Pleistocene (Fig. 3) (Dermitzakis 1990). They became separate islets after the end of Wurm glaciation. The geologic evolution of the islets is reflected on the composition of the malacofauna, which can be characterized as relictual. This is supported by the distribution of *O. aegopinoides* and *P. aff. gradilis* that are common endemics of easternmost Crete and Dionysades, and the 4 cretan endemic species.

The few Aegean endemic species, *D. lasithionensis*, *P. bathytera* and *M. pellita*, reveal an older connection, pre-Messinian, of the whole Cretan area (Crete and its present day satellite islets) with other islands of the Aegean, either Cyclades or south Dodekanisa (Dermitzakis 1990).

The 2 strict endemic species of *Albinaria* cannot be related to the isolation of the islets because the genus *Albinaria* is very diversified and quite problematic as far as its phylogeography is concerned (Giokas, 1996). Also, the two endemic species have been placed within the *teres* group (Nordsieck, 1999); *A. teres* is an endemic species of eastern Crete.

Additionally, the relictual character of the malacofauna of the Dionysades islets is supported by the predominance of cretan and aegean endemics (54%). The synthesis of the malacofauna of Dionysades is similar to that of Crete; where cretan and aegean endemics (54%) also dominate (Vardinoyannis, 1994). On the contrary there are islets around Crete, such as Koufonisi islet group southeast of Crete that has recently emerged (Peters, 1985) where widespread taxa represent 81% of the malacofauna while cretan endemics are limited to 19% and aegean endemics are absent. According to Parmakelis et al. (2003) the malacofauna of Koufonisi islet group is due to dispersal.

The overall study of all the satellite islets of Crete will be very enlightening regarding the different processes establishing the malacofauna on these satellite islets.

## ACKNOWLEDGEMENTS

The present study was funded by the Natural History Museum of Crete. We would like to thank P. Lymberakis and C. Antoniou for their valuable assistance during the field trip.

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# A NEW SPECIES OF *TRUNCATELLINA* (GASTROPODA: VERTIGINIDAE) FROM MOUNT OSSA (=KISSAVOS) (GREECE).

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*Abstract* *Truncatellina cameroni* n. sp. is described from Mt. Ossa in Greece; it is the largest species of the genus described to date. Additionally, *Truncatellina callicratis* and *T. cylindrica* are recorded from Mt. Ossa for the first time.

*Key words* Systematics, new species, *Truncatellina*, Greece.

## INTRODUCTION

*Truncatellina* comprises minute snails distributed in Europe, the Canary and Cape Verde Islands, Caucasus, Central and South-Eastern Asia and Africa (Adam, 1954; Schileyko, 1984, 1998; Van Bruggen, 1994; De Winter & Vermeulen, 1998). The systematics of the genus is based almost exclusively on shell characters (presence/absence, position and form of apertural barriers, surface sculpture, shell size and proportions); the genital characters are practically useless because of the greatly simplified structure of the reproductive system and the frequent aphallism (Pokryszko, 1987, 1990; Van Bruggen, 1994).

The genus includes over 25 species; four of them have been recorded from Greece: *T. rothi* (Reinhardt, 1916), *T. cylindrica* (Férussac, 1807), *T. callicratis* (Scacchi, 1833), and *T. claustralis* (Gredler, 1856). In July of 2001, during fieldwork in 17 sites at Mt. Ossa, we found *Truncatellina* in four of them (Fig. 1). Some of the specimens represented a new species. Its description, as well as new records of the remaining two species are presented below.

The counting of the shell whorls follows Kerney *et al.* (1983). All the measurements were taken with a micrometer lens, stereomicroscope Leica MZ6. Photographs were taken using a digital camera, Olympus camedia C-330 Zoom coupled with Olympus SZX-9 Stereoscope. The following abbreviations of collection names are used in the text: NHMC - Natural History Museum of Crete, Irakleio, NHMW - Natural History Museum, Wrocław University.

*Truncatellina cameroni* Triantis & Pokryszko n.sp.

*Holotype* Adult shell - malacological collection, NHMC50.880.

*Type locality* Mt. Ossa, peak, 1980 m a.s.l., UTM grid coordinates: FK40. Steep slope and limestone, dominated by *Astragalus angustifolium* (site 5 in Fig. 1). M. Mylonas, K. A. Triantis leg., 29. 7. 2001.

*Paratypes* From the type locality: 8 shells (2 adult, 6 subadult) – NHMC50.881; 1 shell – NHMW. From other localities: 1 adult broken shell – NHMC50.882. Between village Spilia and mountain refuge, 1190 m a.s.l., FK40, steep calcareous slope, coniferous forest

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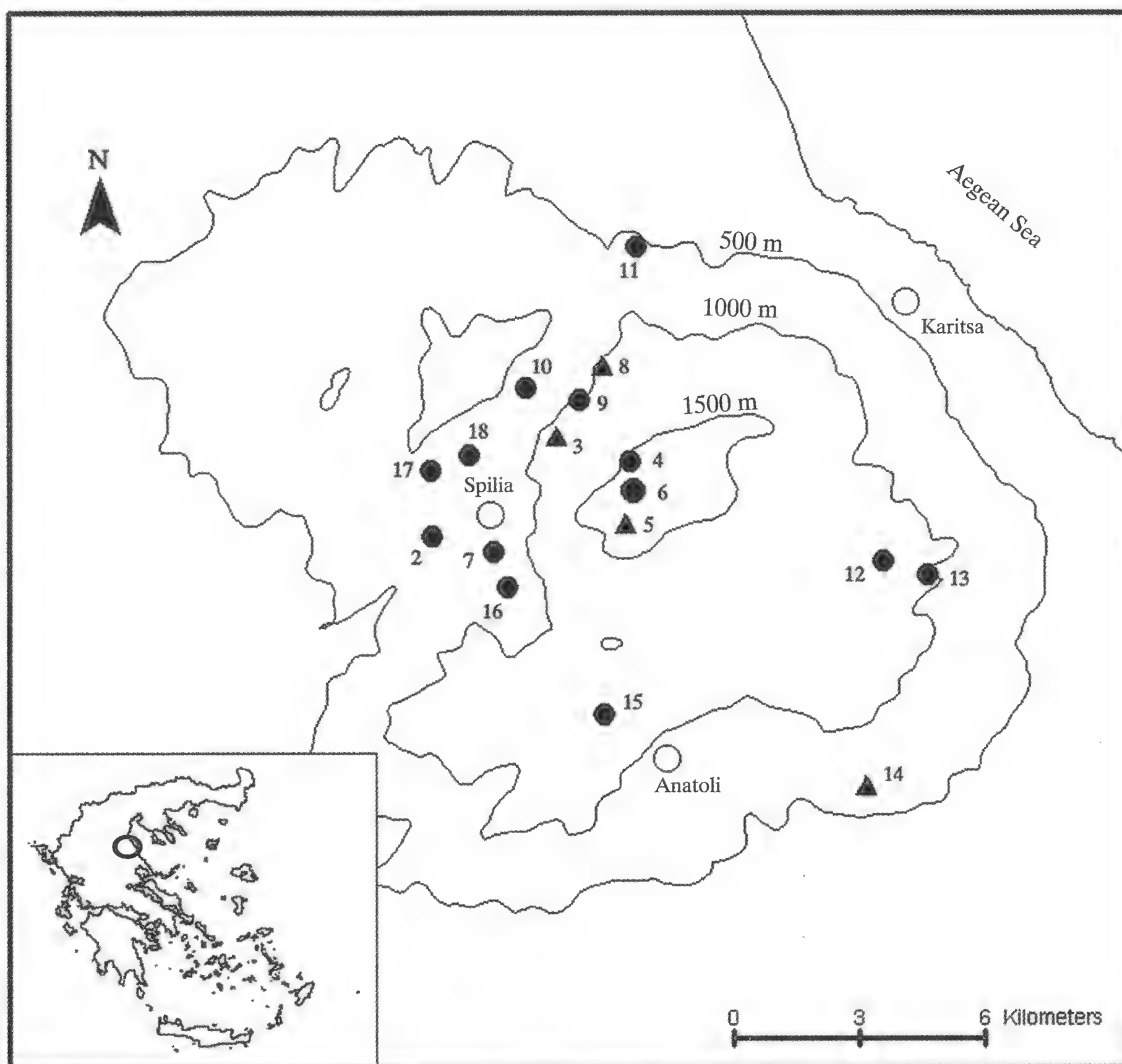


Fig 1 Map of mountain Ossa with the sites surveyed. Triangles indicate the presence of *Truncatellina* species.

of *Abies borisii-regis* and understory of *Quercus coccifera* (site 3 in Fig. 1), M. Mylonas, K.A. Triantis leg., 28.7.2001. 1 adult broken shell – NHMC50.883. 10 km from village Spilia towards Karitsa, 1030 m a.s.l., FK40, gentle calcareous slope, coniferous forest with *Abies* (site 8 in Fig. 1), M. Mylonas, K.A. Triantis leg., 29.7.2001. 1 subadult shell – NHMC50.884. Between Karitsa and Anatoli, 7 km from Anatoli, 700 m a.s.l., FK50, xerophilous maquis (*Quercus coccifera*, *Juniperus oxycedrus*, *Berberis cretica*) with scattered *Platanus orientalis* and *Fagus sylvatica* (site 14 in Fig. 1), M. Mylonas, K.A. Triantis leg., 31.7.2001.

*Derivation of name* The new species is named in honour of Professor R.A.D. Cameron (University of Sheffield), an outstanding malacologist and ecologist.

*Description* The shell is dextral and cylindrical, with a rounded apex and  $5\frac{1}{2}$ -6 whorls. The whorls are moderately convex, the shell surface faintly striated (but not ribbed, contrary to most species of *Truncatellina*), with striae narrowly spaced. The suture varies from moderately deep-to-deep. The body whorl is almost twice higher than the penultimate. The aperture is triangular-ovate, with no apertural barriers. The lip is sharp, its columellar and basal parts slightly reflected; the parietal callus is thin, membrane-like (Fig 2).

*Measurements* Holotype Shell height: 3.17 mm, shell width: 1.67 mm, aperture height: 0.91 mm, aperture width: 0.95 mm, body whorl height: 1.4 mm, height/width ratio: 1.90. Paratypes (5 shells): Shell height: 2.92-3.17 mm, shell width: 1.58-1.75 mm, aperture height: 0.86-1.00 mm, aperture width: 0.86-0.95 mm, body whorl height: 1.3-1.4 mm, height/width ratio: 1.83

*Ecology* The specimens of the new species were found under stones and in the litter, all on calcareous substratum, with vegetation of either coniferous and mixed forest or maquis and alpine shrubs. In sites 8 and 14 the new species was the only *Truncatellina* species found, while in site 3 it was sympatric with *T. callicratis* and *T. cylindrica* and in site 5 with *T. callicratis*, only.

*Distribution* *Truncatellina cameroni* n.sp. is at present known only from Mt. Ossa, altitudes 700-1980 m a.s.l.

*Comparisons and remarks* The combination of characters including the large size, striation instead of ribbing and the absence of apertural barriers make *Truncatellina cameroni* unique among its congeners. Its shell height and width significantly exceed the mean values of corresponding shell parameters of all other members of the genus (Fig. 3), and thus *T. cameroni* is the largest *Truncatellina* described to date. Only very large specimens of the African species *T. pygmaeorum* (Pilsbry & Cockerell, 1933) and the Croatian *T. lussinensis* (Stamol, 1995) may exceed 2.5 mm shell height (cf. Fig. 3). Geyer (1912) mentions abnormal, gigantic shells of e.g. *T. cylindrica*. Such shells have a larger than normal number of whorls, reduced apertural barriers and very often incomplete lip. However, they are not much wider than normal shells, and as a result appear very narrow, with a height/width ratio exceeding 2 (Pokryszko, 1990). The possibility that our shells are abnormal specimens of another *Truncatellina* can be excluded, because some of them have complete lip, the height/width ratio (1.83-1.90) and the number of whorls ( $5\frac{1}{2}$ -6) are within the range typical of most members of the genus, and the material comprises several specimens from four sites, while abnormal shells are extremely rare in populations of *Truncatellina*.

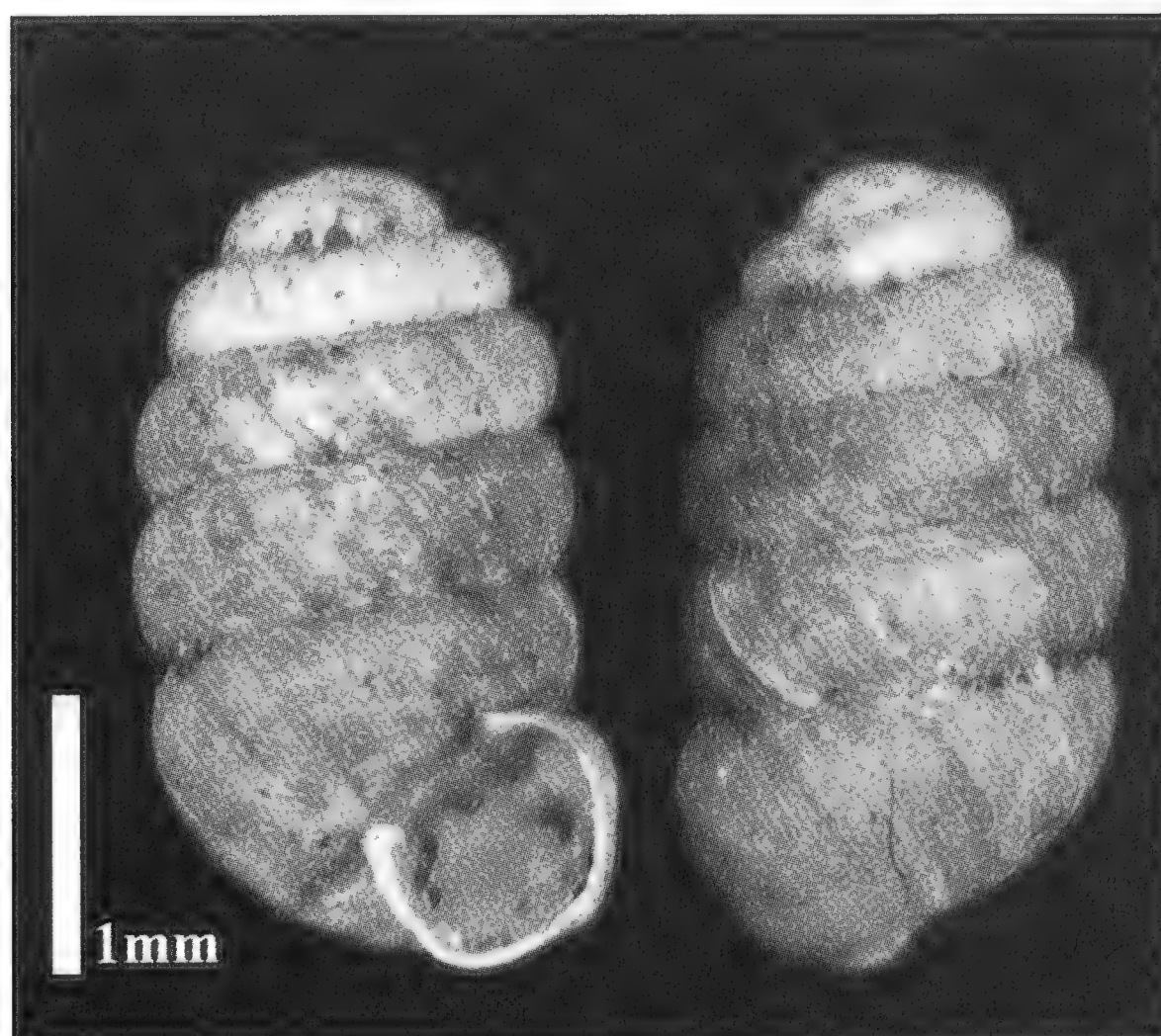
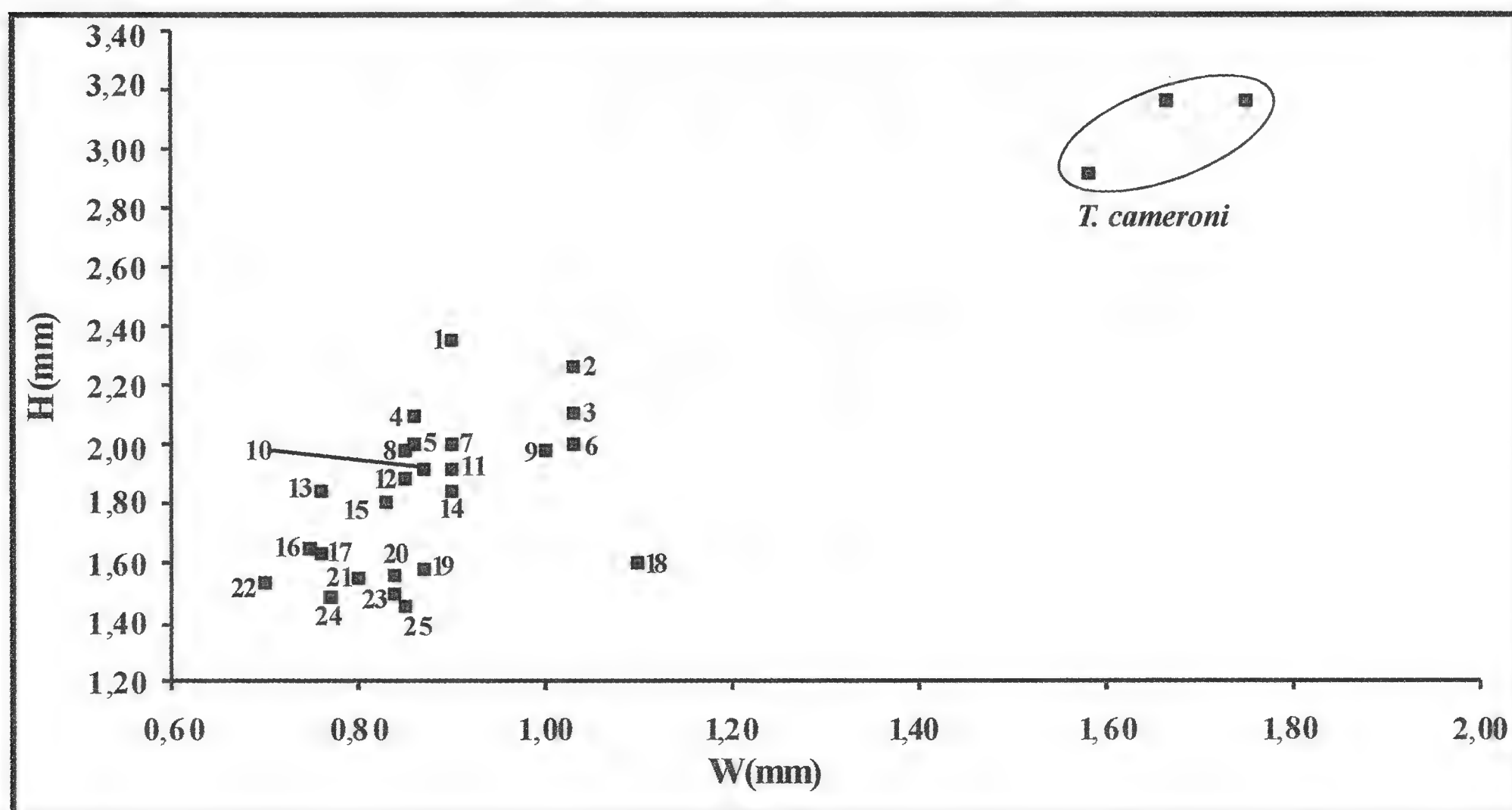


Fig. 2 *Truncatellina cameroni* n.sp. front and back view.



**Fig. 3** Shell height (H) and shell width (W) of *T. cameroni* and other members of the genus. All values are mean values for species. 1: *T. lussinensis* Stamol, 1995 2: *T. adami* Van Bruggen, 1994 3: *T. obesa* Adam, 1954 4: *T. iota* (Melvill & Ponsonby, 1894) 5: *T. ruwenzoriensis* Adam, 1957 6: *T. molecula* (Dohrn, 1869) 7: *T. callicratis* (Scacchi, 1833) 8: *T. naivashaensis* (Preston, 1911) 9: *T. pygmaeorum* (Pilsbry & Cockerell, 1933) 10: *T. ninagongonis* (Pilsbry, 1935) 11: *T. cylindrica* (Férussac 1807) 12: *T. rothi* (Reinhardt, 1916) 13: *T. sykesi* (Melvill & Ponsonby, 1893) 14: *T. costulata* (Nilsson, 1823) 15: *T. upembae* Adam, 1954 16: *T. claustralis* (Gredler, 1856) 17: *T. perplexa* (Burnup, 1908) 18: *T. klemmi* Zilch, 1960 19: *T. biscoittoi* Hutterer & Groh, 1991 20: *T. atomus* (Shuttleworth, 1852) 21: *T. brandti* Zilch, 1960 22: *T. velkovrhi* Stamol, 1995 23: *T. linearis* (Lowe, 1852) 24: *T. pretoriensis* (Melvill & Ponsonby, 1893) 25: *T. lardea* (Jickeli, 1874).

Data sources: 1 & 22 from Stamol, 1995; 2 & 5 from Van Bruggen, 1994; 3, 4, 9, 10, 13, 15, 17, 24 & 25 from Adam, 1954; 6, 19, 20 & 23 from Hutterer & Groh, 1991; 7, 11, 14 & 16 from Kerney et al., 1983; 8 from Adam, 1954 and Van Bruggen, 1994, 12 from Maassen, 1984; 18 & 21 from Zilch, 1960.

*T. cameroni* n. sp. is easily distinguished from the remaining two edentate species of *Truncatellina* recorded from Greece: *T. rothi* and *T. cylindrica*. The shell of *T. cylindrica* is 1.9-2 mm high and 0.9 mm wide (Kerney et al., 1983), that of *T. rothi* does not exceed 2 mm in height and its width is only slightly over 1 mm (Maassen, 1984). Compared to them, *T. cameroni* has its shell by 1/3 higher and almost twice wider. Moreover, the shell of *T. cameroni* is not ribbed, contrary to the other two species, which have a very distinct and regular ribbing. *T. cylindrica obscura* (Mousson, 1859) is a mysterious form described from Janina (Ioannina, Ipeiros) in Greece; the description is incomplete but the only differences mentioned between this form and *T. cylindrica* are a darker colour and a more obtuse apex (but not the size) (Pilsbry, 1920-1921). Other toothless species, though more remote geographically, are *T. himalayana* (Benson, 1863) and *T. micula* (Mousson, 1876). *T. himalayana* resembles *T. cylindrica* and differs from the new species in ribbed shell and size (shell height 1.50-2.16; Pokryszko, unpublished). Besides, finding in Greece a species known practically only from Himalaya and adjacent areas does not seem likely. *T. micula* is a doubtful species, described from Transcaucasia and later allegedly found in the drift of the Maritza river (Bulgaria) (Pilsbry, 1920-1921). Its description is unclear, and it has not been figured, but it is smaller than the new species (shell height up to 2.7 mm), ribbed and has 7-8 whorls.



The only rib-less species known from adjacent areas (but not from Greece) is *T. velkovrhi* Stamol, 1995 from Croatia, but it is small (cf. Fig. 3) and dentate, with two teeth in the aperture.

### ACKNOWLEDGEMENTS

The photograph was taken in the laboratory of Aquaculture of the Biology Department of the University of Crete, with the valuable help of D. G Sfakianakis. We would like also to thank M. Nikolakakis for providing us with the map presented in this paper. An anonymous referee and A. Parmakelis improved the manuscript with comments and suggestions. The present study was funded by the Natural History Museum of Crete and the Biology Department of the University of Crete.

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# TWO NEW ANGIOMPHALIA SPECIES FROM CHINA (PULMONATA: HELICOIDEA) EXTENDING THE EASTERN FRINGE OF THE HYGROMIIDAE

MIN WU<sup>1</sup>

*Abstract* Recognition of two new species in the genus *Angiomphalia* Schileyko extends the distribution of land snails of the family Hygromiidae eastwards to west Xinjiang Province, China. Previously, *Angiomphalia* has only been reported from the western Tianshan region of the former USSR, and the Xinjiang region was thought to have only *Bradybaenidae*. The anatomy of *Angiomphalia* (A.) *takesensis* n. sp. and *Angiomphalia* (A.) *guljaensis* n. sp., are described and figured. The systematics, distribution and microhabitats of paedhoplitine land snails are discussed.

*Key words* Helicoidea, Hygromiidae, *Angiomphalia*, new species, distribution, China.

## INTRODUCTION

The Xinjiang region of China has a rich fauna of helicoid land snails, all of which have until now been grouped within a single family, the *Bradybaenidae*. However, this classification has been based on shell characters alone, as the anatomy of the helicoids from this region has not previously been investigated (e.g., Ancey, 1884; Möllendorff, 1884, 1899; Gude, 1902a, 1902b; Weber, 1910; Ping & Yen, 1932; Yen, 1935, 1939; Zilch, 1968). Classification within the Helicoidea is notoriously unreliable when not based on detailed anatomical information — many conchological characters have evolved in parallel several times in different groups, and should only be employed in systematic reconstruction after very careful consideration (e.g., Schileyko, 1978; Nordsieck, 1987 and pers. comm.). The present paper describes the anatomy of two new species of land snail from the Xinjiang region belonging to the genus *Angiomphalia* Schileyko 1978, of the family Hygromiidae. This is the first record of hygromiids from China, and represents the most easterly distribution records for the family.

The hygromiid genus *Angiomphalia* was first described by Schileyko (1978), with a range restricted to the mountainous areas of Kyrgyzstan, Kazakstan, Tadzhikistan and Uzbekistan in the former USSR. Based on differences in shell features, especially the apertural tooth, and the degree of development of the vaginal apparatus, characterizedly paired appendiculae, Schileyko divided this genus into two subgenera: *Angiomphalia* (s. str.) with six species, and *A. (Lentiga)* Schileyko 1978 with two species having more complex appendiculae. Together with a second genus, *Paedhoplita* Lindholm 1927 containing three species penial papilla smaller than that in *Angiomphalia* and lacking a penial gland, they formed the new subfamily Paedhoplitinae Schileyko, 1978.

Schileyko's Paedhoplitinae has a confused history. Nordsieck (1987) synonymised it with Euomphaliini, because both these groups have a couple of vaginal appendiculae. Nordsieck included this enlarged tribe into the subfamily Monachinae, which is characterized by the transformation of the dart sacs into appendiculae. He characterized the various groups within the Monachinae — the *Monacha* group, the *Euomphalia* group (including the *Paedhoplita* group), and the *Cochlicella* group — by the possession of the two appendiculae, each of which consist of a basal portion and a terminal appendix which are more-or-less distinctly separated. He considered the structure of the two appendiculae in the Euomphaliini to be plesiomorphic in respect to that of the appendiculae in the Monachinae and Cochlicellinae.

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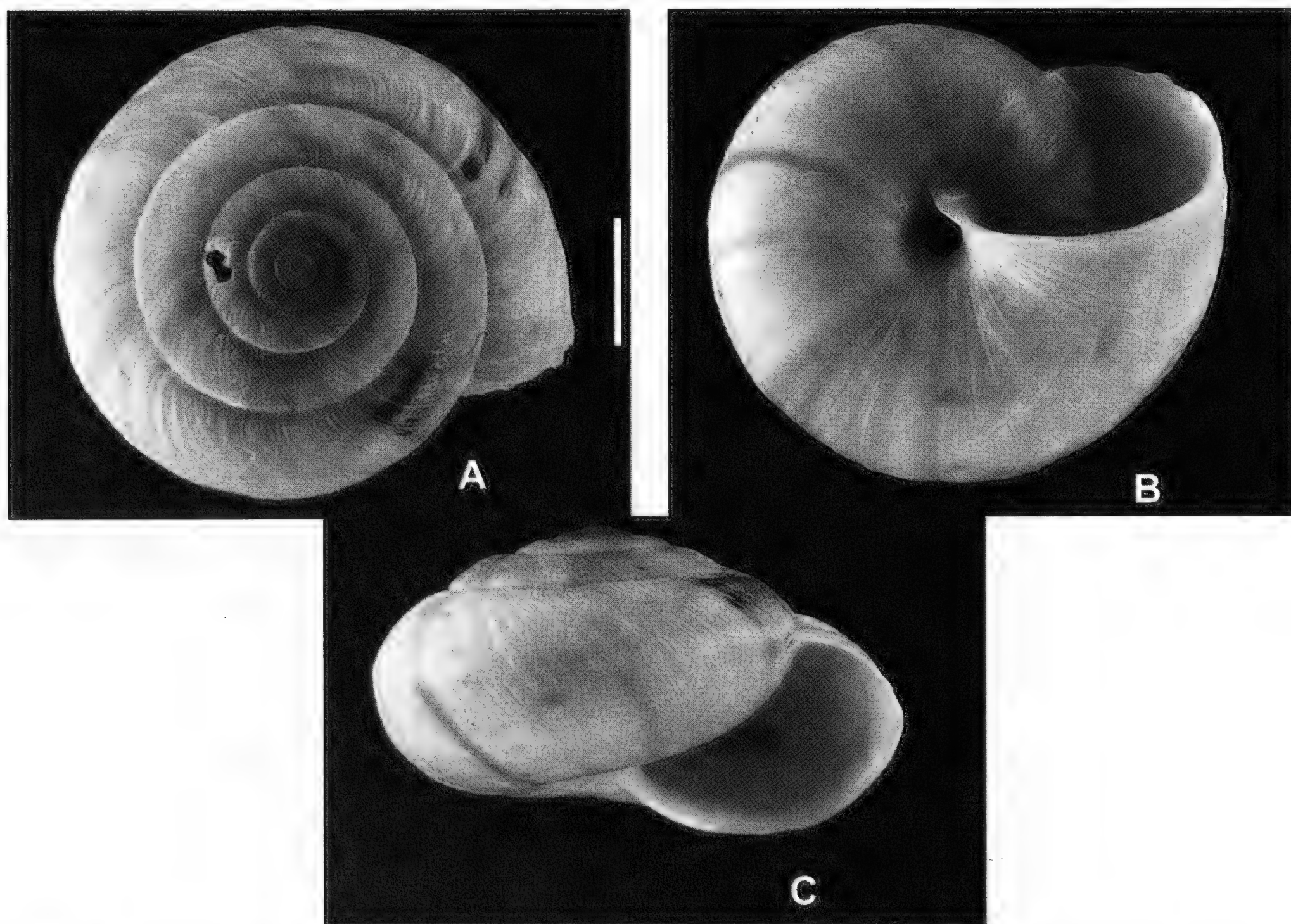


Schileyko (1991: 214), however, argued that the structure of the vaginal appendages of the Euomphalinae and Paedhoplitinae differs, as in the former it is the upper pair of dart sacs that is reduced, whereas in the latter it is the lower pair. Nordsieck (1993) subsequently changed his earlier classification, and followed Schileyko in grouping *Angiomphalia* and *Paedhoplita* (in which he now included *Lentiga*) in a tribe Paedhoplitini, within the subfamily Geomitrinae. The Paedhoplitinae sensu Schileyko (1978) (the Paedhoplitini of Nordsieck, 1993) can be considered a monophyletic group because of the apomorphic structure of the female genitalia, as described by Schileyko (1978, 1991).

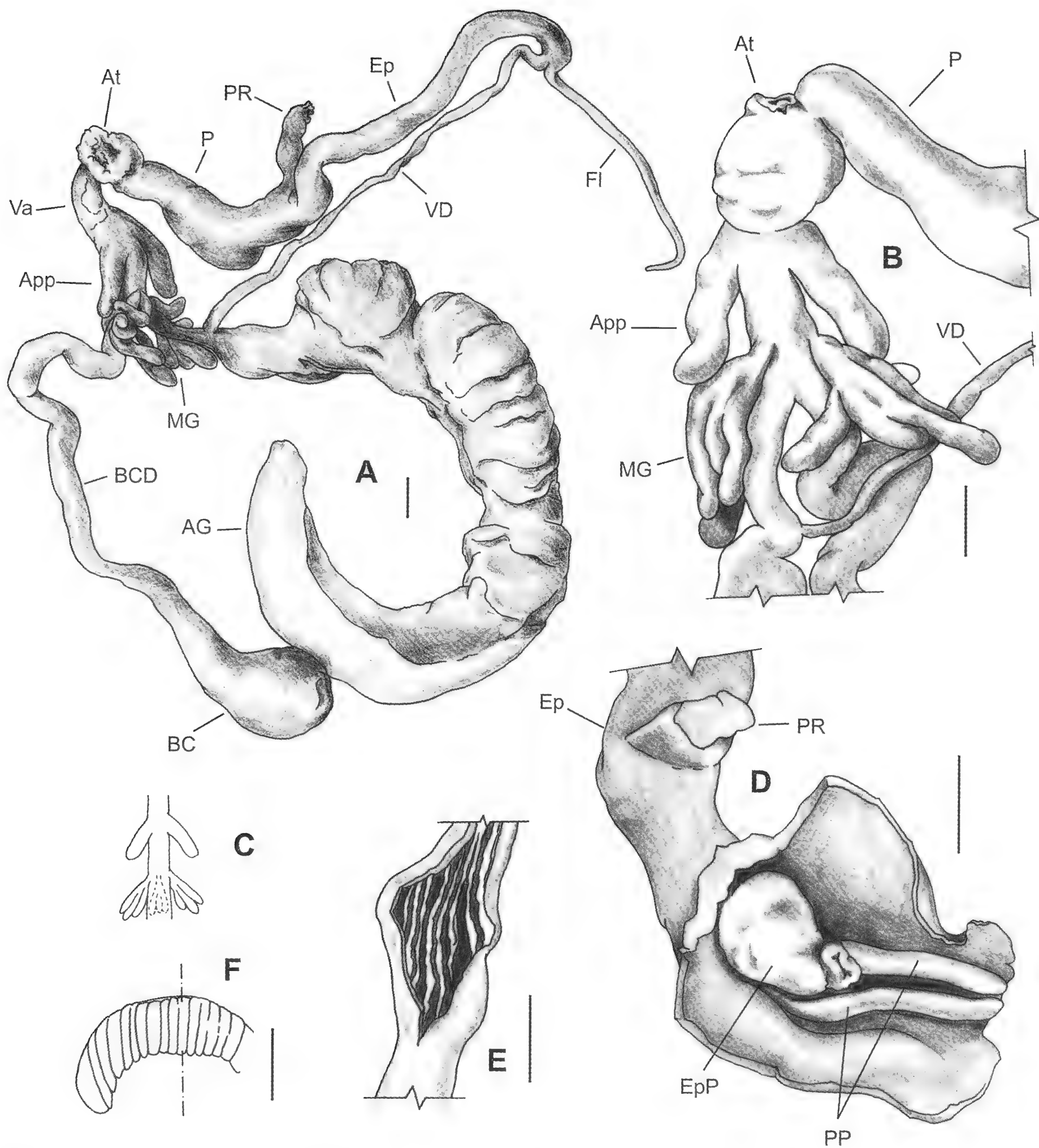
## MATERIAL AND METHODS

All specimens listed are preserved in 70% ethanol after relaxation, and are housed in the Institute of Zoology, Chinese Academy of Sciences (IZCAS). Shell and genital measurements were taken with 0.01 mm and 0.1mm accuracy respectively. Whorls were counted as described by Kerney and Cameron (1979). Descriptions of coloration and measurements of soft parts were based on ethanol-preserved material. All the materials are old spirit material collected by Chen D.N. and Gao J.X. during 1974 to 1975.

The abbreviations in text and figures: AG, albumen gland; AH, aperture height; App, vaginal appendicula; At, atrium; AW, aperture width; BC, bursa copulatrix; BCD, duct of bursa copulatrix; Chen & Gao, Chen D.N. & Gao J.X.; diam., diameter; Ep, epiphallus; Fl, flagellum; PP, penial papilla; max., maximum; MG, mucous glands; P, penis; PG, penial



**Figure 1** *Angiomphalia (A.) takesensis* n. sp., holotype, IZCAS00133-spec.1, shell. A, apical view; B, basal view; C, apertural view. Bar equals 5 mm.



**Figure 2** *Angiomphalia (A.) takesensis* n. sp., anatomy. A, general view of genitalia, holotype, IZCAS00133-spec.1; B, detailed terminal genitalia, paratype, IZCAS00133-spec.2; C, Schematic of terminal genitalia; D, opened penis, showing penial papilla and penial pilaster wall, paratype, IZCAS00133-spec.2; E, opened epiphallus, paratype, IZCAS00133-spec.2; F, jaw, holotype, IZCAS00133-spec.1. A-E, bars equal 1 mm; F, bar equals 0.5 mm.

TABLE 1  
Measurements and counts of types of *Angiomphalia (A.) takesensis* n. sp. (length in mm)

	Holotype	Range	Mean ±sd.	N
Height	11.01	8.76-11.14	9.97 ±0.53	
Diam. (maj.)	17.23	14.40-17.53	16.10 ±0.75	
Whorls	6.00	5.50-6.25	5.79 ±0.13	
PWh	1.50	1.25-1.75	1.49 ±0.11	
AH	9.09	7.75-9.30	8.53 ±0.42	67
AW	8.55	6.19-8.55	7.22 ±0.51	
Umb. Diam.	1.33	0.40-1.57	0.95 ±0.20	
RHD	0.64	0.57-0.70	0.62 ±0.02	
RUD	0.08	0.03-0.09	0.06 ±0.01	



gland; PR, penial retractor; PP, penial pilaster; PWh, protoconch whorl number; RHD, ratio of shell height / max. shell diameter; RUD, ratio of umbilicus diam./max. shell diam.; Va, vagina; VD, vas deferens.

## SYSTEMATIC DESCRIPTION

FAMILY HYGROMIIDAE TRYON, 1866  
SUBFAMILY PAEDHOPLITINAE SCHILEYKO, 1978

Genus *Angiomphalia* Schileyko, 1978

*Type species* *Helix regeliana* Martens 1882 by original designation.

*Angiomphalia (Angiomphalia) takesensis* n. sp.  
Figs. 1, 2 & 6

*Holotype* IZCAS00133-spec.1, Takes, China, 5/8/1974.

*Paratypes* IZCAS00133-spec.2~52, 5/8/1974. 15 adults, IZCAS00168-spec.1~15, Yemadu, Takes, China, coll. date unknown. Seven specimens were dissected.

*Other material* Twenty-seven immature snails from IZCAS00171, Takes, China, 5/8/1974.

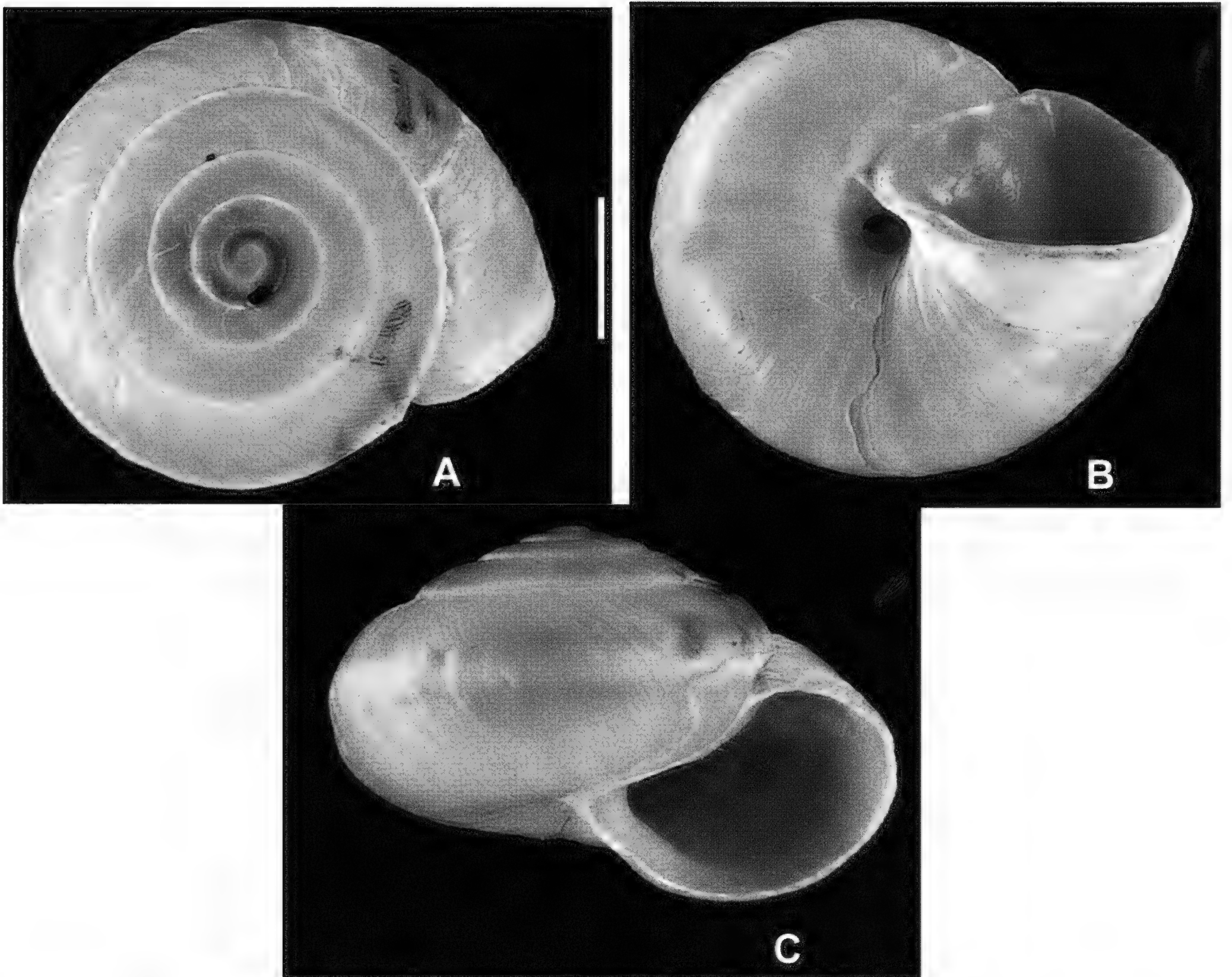
*Diagnosis* Penial gland absent. Inside penis with two thick and smooth penial pilasters. Epiphallic papilla strong. Mucous glands about as long as appendiculae; with 3 clusters, each with 2 mucous tubes. Appendicula situated at midpoint of atrium and mucous glands insertion.

*Description* Shell (Fig. 1A-C, Tab. 1) depressed, globular, dextral, thick and solid. Whorls convex, and increasing rather slowly. Suture deep. Umbilicus narrow. Columella oblique. Columellar lip somewhat dilated, slightly covering umbilicus. Adult periostracum hairy, but typically smooth due to abrasion; young shell with hairs. Spiral furrows regularly and densely distributed. Growth lines distinct, dense, not accompanied by irregular thickenings. Protoconch with irregular axial wrinkles. Immature shells distinctly angulated at periphery; body whorl of adults weakly angulated and slightly descending. Lower part of shell convex. Aperture very broadly lunate, moderately oblique. Lip simple and thickened basally. Aperture seldom expanded. Peristome thin. Callus glossy and distinct. Shell faintly shiny, opaque, except with some yellowish brown striae, accompanied with sparsely and irregularly scattered brown spots. Protochoch in light reddish brown; one pale indistinct shell band present at periphery.

Jaw (Fig. 2F) arcuate, ribbed; with ca. 20 ribs indenting the concave margin. Ribs contiguous, rather narrow.

Genitalia (Fig. 2A-E). Penis rather long, swollen (Fig. 2A & B). Inner wall of penis with two major pilasters, thick and smooth; the remaining part of inner penial wall more or less smooth (Fig. 2D). Penial papilla conical, smooth (Fig. 2D). Penial gland absent (Fig. 2D). Epiphallus rather thick, moderately long. Inner wall of epiphallus consisting of several (usually less than ten) similar pilasters (Fig. 2E). Penial retractor thick, short (Fig. 2A, D). Flagellum smooth on surface, thin, moderately long, slowly





**Figure 3** *Angiomphalia (A.) guljaensis* n. sp., holotype, IZCAS00170-spec.1, shell. A, apical view; B, basal view; C, apertural view. Bar equals 5 mm.

tapering and apically sharp (Fig. 2A). Two empty appendiculae situated on opposite sides of mid-part of vagina (Fig. 2A-C). Appendiculae rather small, elongated, with initial part tightly adhering to vagina. Mucous glands arranged in 3 distinct clusters, far from appendiculae; two clusters situated directly below corresponding appendiculae, third cluster inserting on vagina between other two clusters (Fig. 2C). Each cluster as long as appendicula, with rather short but distinct stalk; inserting on vagina near base of bursa copulatrix duct. Lobules radially arranged, each usually with 3 finger-shaped tubes; tubes never expanded terminally. Bursa copulatrix elongated; not differentiated from its duct. Duct of bursa copulatrix moderately long, inserting high up on vagina. Lobes of gonad palmate. Dimensions of holotype (IZCAS00133-spec.1): Penis 6.4 mm; penial retractor 2.2 mm; epiphallus 10.0 mm; flagellum 7.2 mm; vas deferens 11.3 mm; distance from atrium to the tip of appendiculae 4.3 mm; free part of appendiculae 2.3 mm; mucous glands 2.8 mm; vagina 4.1 mm; Duct of bursa copulatrix 1 duct (bursa copulatrix included) 16.1 mm.

*Derivation of name* After the type locality Takes, Xinjiang, China.

*Distribution* Takes County (43°12'N, 81°48'E), Xinjiang, China, 1200 m above sea level.

*Ecology* The snails of lot IZCAS00168 were recorded living near the banks of Takes River.

**Remarks** Except the absence of the penial gland in this species, anatomically and conchologically this species most resembles *A. (A.) caelestimontana* (Tzvetkov, 1940) (Schileyko, 1978, Plate XVII, 163), which inhabits the western Tianshan Mountains. They resemble each other in the relatively smooth penial papilla, although in the new species the papilla is somewhat shorter (Schileyko, 1978, Figs. 386, 388). However, in all the dissected type material of the new species no distinct penial gland was found. The mucous gland formula of Schileyko (1978) is 3 (number of branches) x3 (tubules of each branch) in the new species, rather than 4x2 in *A. (A.) caelestimontana*. Table 3 shows the comparison with other paedhoplitine species. The hairs on periostracum of this species are about 3 times longer than those of *Angiomphalia (A.) guljaensis* n. sp..

*Angiomphalia (Angiomphalia)*  
*guljaensis* n. sp.

Figs. 3-6

**Holotype** IZCAS00170-spec.1, Piliqi, Gulja, China, 31/3/1975.

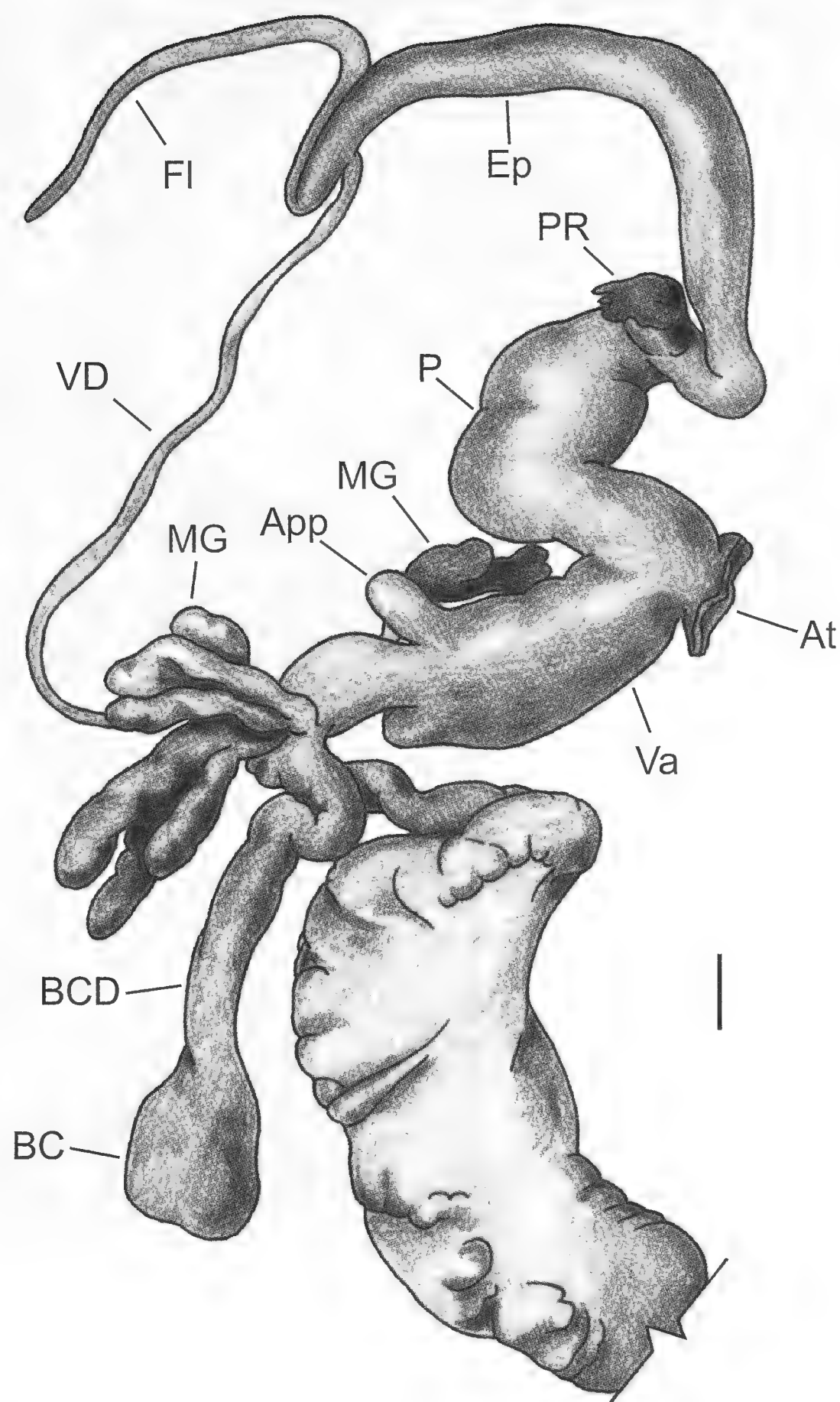
**Paratypes** IZCAS00170-spec.2~9, Piliqi, Gulja, China, 31/3/1975;

IZCAS00169-spec.2~14, Piliqi, Gulja, China, 31/3/1975; IZCAS00172-spec.1, town of Gulja, China, 26/4/1974. Four specimens were dissected.

**Other material** 13 immature shells of IZCAS00170, Piliqi, Gulja, China, 31/3/1975; three immature shells from IZCAS00172, town of Gulja, China, 26/4/1974; 8 immature specimens from IZCAS00169, Piliqi, Gulja, China, 31/3/1975.

**Diagnosis** Penial gland absent. Inside penis penial pilasters undifferentiated. Epiphallic papilla strong. Mucous glands longer than appendiculae; with 4 clusters, each with 2 mucous tubes. Appendicula situated near midpoint of atrium and mucous glands insertion.

**Description** Shell (Fig. 3A-C, Tab. 2) depressed, globular, rather raised, dextral, thick and solid. Whorls moderately convex, increasing rapidly. Suture not markedly impressed.



**Figure 4** *Angiomphalia (A.) guljaensis* n. sp., holotype. General view of genitalia. IZCAS00170-spec.1. Bar equals 1 mm.



Umbilicus fairly narrow. Columella oblique. Columellar lip not dilated and slightly covering umbilicus. Adult shell with hairy periostracum, although usually smooth due to abrasion; young shell with short hairs. Spiral furrows regularly and densely distributed. Growth line not accompanied by any irregular thickening. Protoconch finely granulose; sometimes forming wrinkles. Teleoconch smooth. Immature shells sharply angulated at periphery. Body whorl very large, more or less descending and weakly angulated at periphery. Base of shell convex. Aperture very broadly lunate, moderately oblique. Lip simple and thickened basally. Aperture slightly expanded below. Peristome rather blunt. Callus distinct and thick. Shell rather shiny, opaque, uniformly dirty white with reddish tinge. One white band present slightly above periphery, in some specimens band absent on last 1/2 whorl.

Jaw (Fig. 5F) arcuate; ribbed; with ca. 22 ribs indenting the concave margin. Ribs contiguous and rather narrow.

Genitalia (Figs. 4, 5A-E). Penis short, extremely swollen (Fig. 4). Inner wall of penis with more than 10 penial pilasters (Fig. 5D). Penial gland absent (Fig. 5D). Penial papilla cylindrical, basally expanded, top of trunk scaly, base with numerous fine layers forming a laminated structure (Fig. 5D). Epiphallus thick, moderately long (Fig. 4). Network consisting of several pleats forming inner structure of epiphallus (Fig. 5E). Penial retractor thick, fairly short. Flagellum sharp, smooth, thin, moderately long, gradually tapering (Fig. 4). Two empty nipple-shaped appendiculae situated at middle of the vagina (Figs. 4, 5A-C). Mucous glands consist of 4 mucous clusters, more than 3-times longer than the free part of appendiculae; stalk of each cluster short but distinct; far from appendiculae; arranged in circle near insertion of bursa copulatrix duct. Each cluster comprising 2 finger-shaped tubes which are not expanded distally (Figs. 4, 5A, 5B). Bursa copulatrix oval, clearly differentiated from its duct, which is rather short and thick. Dimensions of holotype (IZCAS00170-spec.1): Penis 6.3 mm; penial retractor 1.0 mm; epiphallus 11.4 mm; flagellum 5.0 mm; vas deferens 13.8 mm; distance from atrium to the end of appendiculae 4.9 mm; free part of appendicula 1.0 mm; mucous glands 3.6 mm; vagina 4.9 mm; Bursa copulatrix duct and bursa copulatrix 7.6 mm.

*Derivation of name* After the type locality, Gulja, Xinjiang, China.

TABLE 2  
Measurements and counts of types of *Angiomphalia* (*A.*) *guljaensis* n. sp. (length in mm)

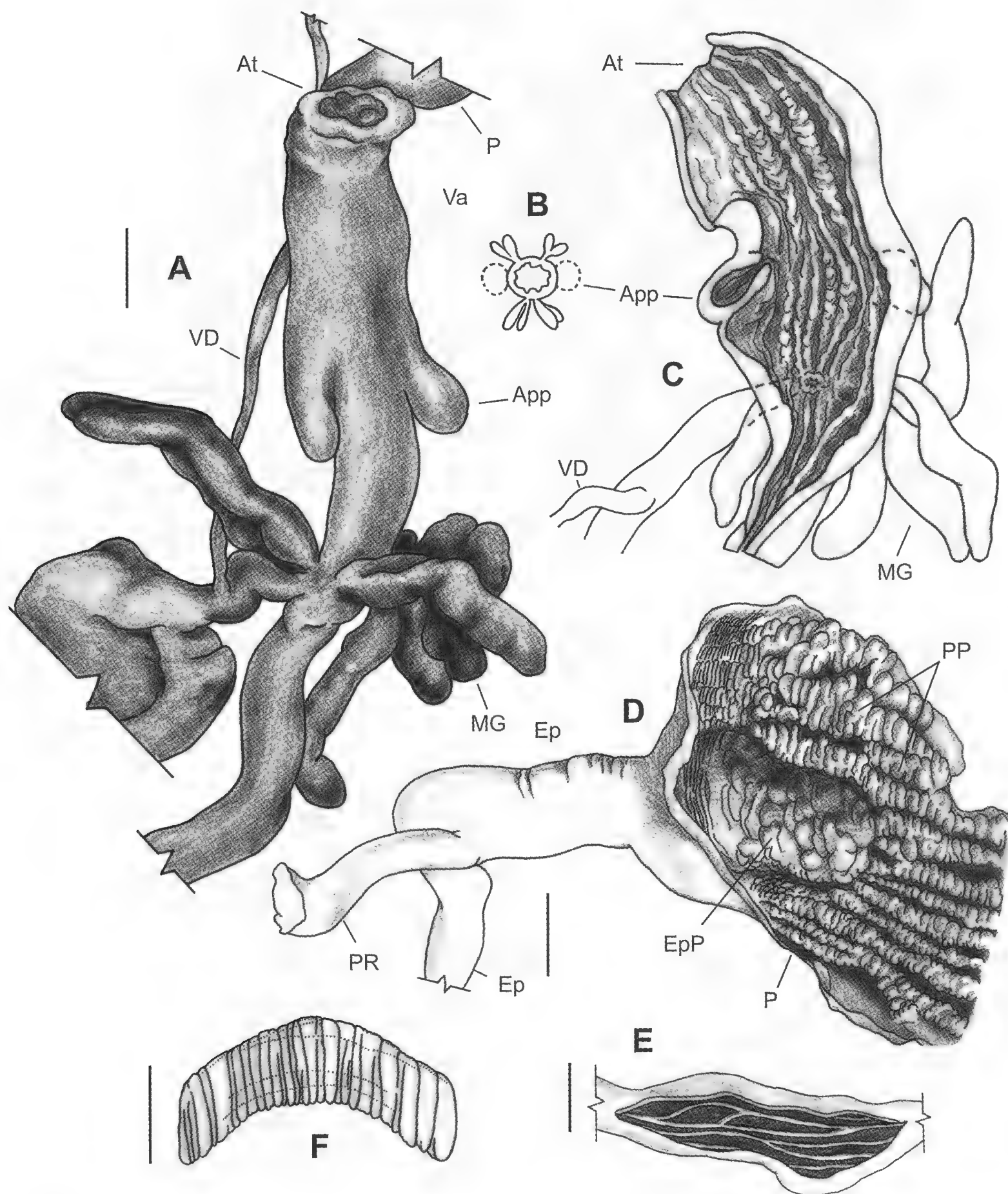
	Holotype	Range	Mean ±sd.	N
Height	11.74	11.07-12.88	11.91 ±0.52	
Diam. (maj.)	17.30	16.06-19.66	17.09 ±0.84	
Whorls	6.00	5.75-6.38	6.07 ±0.16	
PWh	1.50	1.50-1.75	1.62 ±0.12	
AH	9.17	8.32-10.73	9.18 ±0.56	24
AW	7.75	7.16-9.53	8.20 ±0.62	
Umb. Diam.	1.29	0.49-1.86	1.17 ±0.33	
RHD	0.68	0.65-0.75	0.70 ±0.02	
RUD	0.07	0.03-0.10	0.07 ±0.02	



*Distribution* Piliqi, Gulja (44°00'N, 81°48'E), China

*Ecology* This species occurs on mountains between 760-1736 m elevation. It is occasionally found in spruce forests, but occurs most commonly in meadows with fallen calcareous rocks.

*Remarks* Anatomically, the absence of penial glands, and the nipple-shaped appendiculae distinguish this species from all known *Angiomphalia* species (Table 3). In this species, two empty nipple-shaped appendiculae, situated at the middle of the vagina, are proportionally smaller than those of *Angiomphalia* (*A.*) *takesensis* n. sp..



**Figure 5** *Angiomphalia* (*A.*) *guljaensis* n. sp., anatomy. A, terminal genitalia, holotype, IZCAS00170-spec.1; B, schematic of terminal genitalia, showing relative situation of female apparatus (appendiculae+mucous glands); C, exposed vagina and one of two appendiculae, paratype, IZCAS00170-spec.4; D, opened penis, showing penial papilla and penial inner wall, paratype, IZCAS00170-spec.2; E, exposed epiphallus, paratype, IZCAS00170-spec.2; F, jaw, holotype, IZCAS00170-spec.1. A-E, bars equal 1 mm; F, bar equals 0.5 mm.

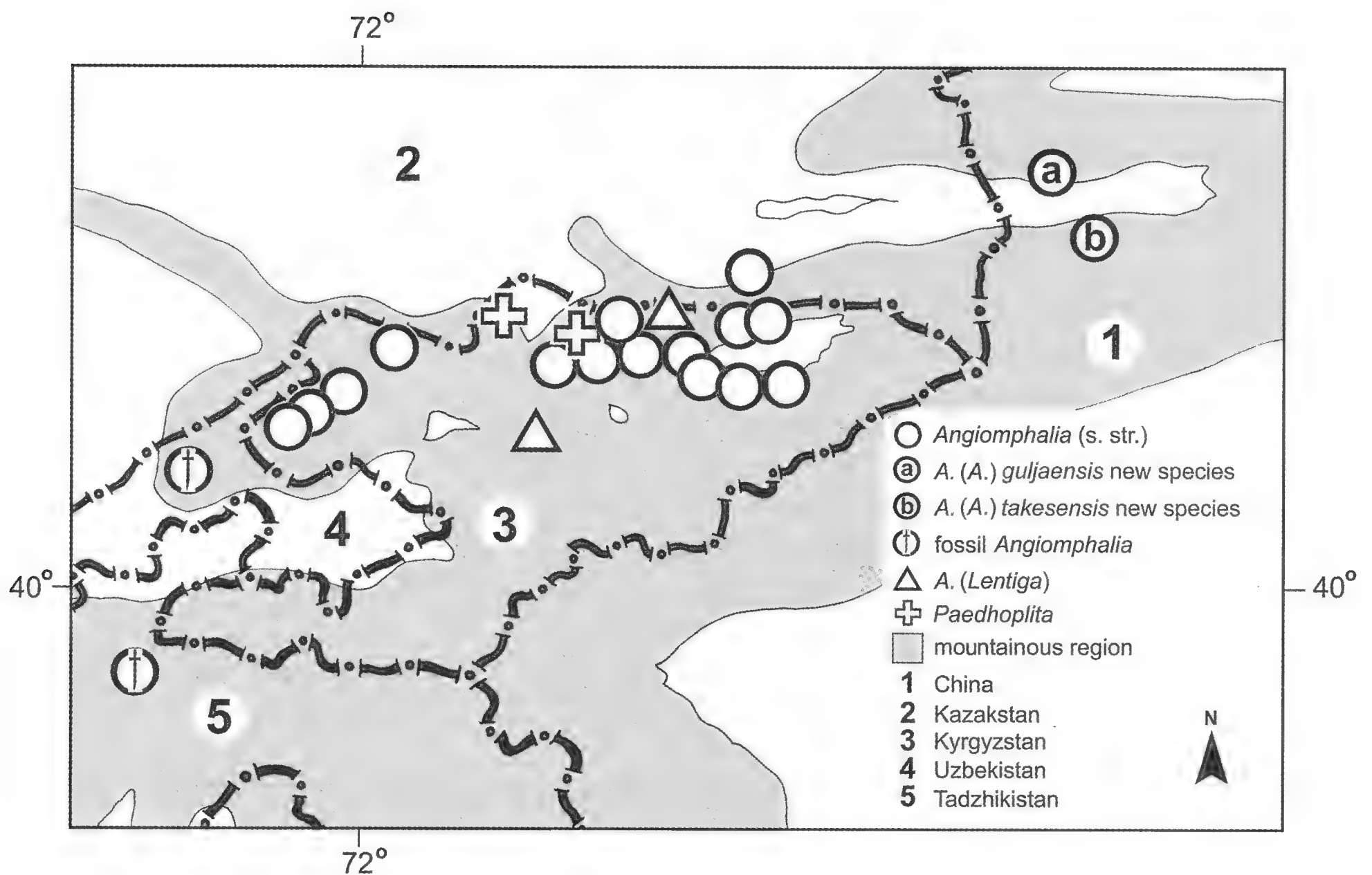


Figure 6 Distribution map of known paedhoplitine species.

## DISCUSSION

### GENERIC STATUS OF THE NEWLY PROPOSED SPECIES

According to Schileyko (1978), the characters used for determining the subdivisions within the paedhoplitine snails are those of the terminal genital anatomy and the shell. *Angiomphalia* sensu lato and *Paedhoplita* can be generally distinguished by the degree of development of the penial papilla (Schileyko, 1978), and the presence or absence respectively of the penial gland. These two genera can also be distinguished by shell characters, since *Paedhoplita* develops an apertural tooth, which *Angiomphalia* lacks. The two subgenera of *Angiomphalia*, *Angiomphalia* (*Angiomphalia*) and *A. (Lentiga)* can be separated on the size and structure of the vaginal appendiculae, which are believed to be reduced dart sacs. Nordsieck accepted Schileyko's generic grouping but placed *Lentiga* in *Paedhoplita* rather than in *Angiomphalia*. However, the taxonomic framework erected by Schileyko (1978) is adopted here as the systematic basis for considering the new species.

The shells of the new species resemble those of *Angiomphalia* (A.) by the virtual absence of an apertural tooth and also by having a periphery that is rounded, rather than sharply angulated above it as in *Paedhoplita*, or bluntly angulated above the periphery as in *Angiomphalia* (*Lentiga*). However, from the morphology of their terminal genitalia alone, it is difficult to determine to which genus-group the new species belong. The range of development degree of penial gland in the species of *Angiomphalia* sensu stricto described by Schileyko (1978) shows there is much variation for the development level of penial gland: *A. (A.) exasperata*, for example, has a pair of penial glands, whereas *A. (A.) seductilis* has one, and for *A. (A.) almalensis*, it shows "... the penial gland only develops in a very few cases ...". For this reason, the lack of the penial gland, showed in the two new described species, is provisionally treated as one of the character states of the character development of penial gland. Consequently, although the new species

share some anatomical characters with *Angiomphalia* (such as the expanded penial papillae) and some with *Paedhoplita* (loss of the penial gland), they are here provisionally placed in *Angiomphalia* in view of the similarity of the shell, and of the considerable variation shown in the development of the penial gland encompassed by described *Angiomphalia* s.s. However, aspects of the anatomy and conchology of the two new Chinese species make the presently accepted generic and subgeneric grouping scheme within the Paedhoplitinae an open question, and may go some way to explain the lack of agreement in taxonomic interpretation between Schileyko and Nordsieck. A greater range of anatomical material, illustrating intra- as well as inter-specific variation, is required before a comprehensive revision of this group can be undertaken.

#### DISTRIBUTION OF PAEDHOPLITINAE

All paedhoplitine land snails dwell in high mountain regions connecting Kyrgyzstan, Kazakstan, Tadzhikistan, Uzbekistan and China. Its eastern border is formed by the Tianshan Mountains (also known as “Tien-Shan”) within China, which include the Borohoro and Kokirgin Mountains to the north, and the Halik and Narat Mountains to the south. The southwestern border of the distribution of the group, if the fossil localities are included, is the northwestern part of the Pamir range, situated in Tadzhikistan. To the northwest, their range is limited by the high ridges of Kyrgyzstan Mountains (Fig. 6, mountain chains not labeled).

The species are known to live at altitudes ranging from 760 m and over 2,600 m, but their preferred habitats are the lower slopes of the mountains and they have never been recorded in the very highest ridges of the region (Schileyko, 1978; this study). These continuous mountain crests thus act as effective barriers to dispersal, isolating the various taxonomic groups. On this basis, the overall range of the Paedhoplitinae can be divided into three sub-regions separated by mountain ridges with elevations well above 3,000 m and typically covered with snow or ice throughout the year. These sub-regions are: 1. The region enclosed by Borohoro, Halik, South Tianshan, Talasskij Alatau and Ferganskij Mountains; 2. The region enclosed by Ferganskij, Talasskij Alatau and Alajskij Mountains; 3. The region bounded to the south by Kyrgyzstan Mountains in the vicinity of northern low hills.

The extant species of *Angiomphalia* sensu lato are all found in the first region, which is mainly formed by the ridges surrounding the Issyk-Kul Lake and has a different microclimate from the other two regions. Fossil *Angiomphalia* are found in Pliocene deposits in Tashkent, in the Gissarskom Mountains and along Zarmas-Saj, in the second region. *Paedhoplita* species are restricted to the third region.

#### ACKNOWLEDGEMENTS

I am grateful to Mr Hartmut Nordsieck from SMF and Dr Peter B. Mordan from BMNH for offering many helpful suggestions. Dr Edmund Gittenberger of the National Museum of Natural History, Leiden, kindly provided important literature. Dr Larisa A. Prozorova from the Far Eastern Branch of Russian Academy of Sciences, generously provided literature and carefully checked the map. Special thanks go to Dr Folco Giusti (Siena University, Italy) for reviewing the manuscript and providing crucial and constructive comments. I am indebted to Dr Minmin Li who kindly translated the involved Russian literature for me. The study is financially supported by the National Natural Science Foundation of China (NSFC, No. 30100017).



TABLE 3

Comparison of the main genital and shell characters in *Angiomphalia* and *Paedhoplita* species. Symbols: + yes; - no; ? unknown;

dCCharacters									
Species		PG present*	PP expanded*	App. complicated	App. with large size*	Mucous glands (cluster×tube number)	PP differen- tiated	Aperture toothed*	Periphery angulate*
<i>A. (A.) copiosa</i> Schileyko, 1978		+	+	-/+	+	4×2	-	-	+
<i>A. (A.) caelestimontana</i> (Tzvetkov, 1940)		+	+	-/+	+	4×2	+	-	-
<i>A. (A.) exasperata</i> Schileyko, 1978		+	+	-	-	4×1-2	-	-	-
<i>A. (A.) regeliana</i> (Martens, 1882)		+	+	-	-	3-4×2	-	-	-
<i>A. (A.) almalensis</i> Schileyko & Uvalieva, 1978		-/+**	+	?	-	2×3-4	-	-	-
<i>A. (A.) seductilis</i> (Westerlund, 1898)		+	+	-	-	2×2-3	-	-	-
<i>A. (L.) lentina</i> (Martens 1885)		+	+	+	+	4×2-3	-	-/+***	+
<i>A. (L.) buamica</i> (B. Tzvetkov & E. Tzvetkova 1943)		+	+	+	+	2-3×2	+	-/+***	+
<i>P. laminata</i> Lindholm, 1927		?	?	?	?	?	?	+	+
<i>P. lindholmi</i> B. Tzvetkov & E. Tzvetkova 1943		-	-	-	-	2×1-2	-	+	+
<i>P. kirgisensis</i> Licharev & Rammelmeyer 1952		?	?	?	?	?	?	+	+
<i>A. (A.) takesensis</i> n. sp.		-	+	-	+	3×3	+	-	+
<i>A. (A.) guljaensis</i> n. sp.		-	+	-	-	4×2	-	-	-

\*Characters used by Schileyko (1978) in the establishment of Paedhoplitinae; \*\* in *A. (A.) almalensis*, the penial gland seldom develops except in very few cases; \*\*\* In *A. (L.) lentina* and *buamica*, the lower lip is internally thickened but there is no true apertural tooth

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# ON THE DISTRIBUTION AND ECOLOGY OF *VERTIGO SUBSTRIATA* (JEFFREYS), *VERTIGO MODESTA ARCTICA* (WALLENBERG), *VERTIGO LILLJEBORGI* (WESTERLUND) AND *VERTIGO ALPESTRIS* ALDER IN FRANCE AND ON THE IBERIAN PENINSULA

TED VON PROSCHWITZ<sup>1</sup>

*Abstract* Museum material and literature data on *Vertigo*-species from France and the Iberian Peninsula have been revised and critically evaluated. Distribution maps based on all available data for four, in this area rare and poorly known, species: *Vertigo substriata*, *V. modesta arctica*, *V. lilljeborgi* and *V. alpestris* are presented. The distribution and ecology of the species in the area are discussed. Two species are restricted to higher altitudes in the Pyrenees: *V. modesta arctica* (3 localities) and *V. lilljeborgi* (2 localities - first record for Spain). *V. substriata* and *V. alpestris* both have a wider distribution, but are very rare and their occurrences scattered. *V. alpestris* is restricted to the northern and eastern parts of France, *V. substriata* occurs also in the Pyrenees and northern Spain and has an isolated occurrence in the south (Sierra Nevada). The total distribution of both species is discussed and North and Middle European is considered a good characterisation of both. *Vertigo Baudoni* Massot, 1872 is a synonym of *V. substriata*. *Vertigo acheila* Servain, 1880 is a synonym of *V. pygmaea* and not of *V. alpestris* or *V. moulinsiana* as previously supposed.

*Key words* Distribution, ecology, France, Iberian Peninsula, Spain, *Vertigo alpestris*, *Vertigo lilljeborgi*, *Vertigo modesta arctica*, *Vertigo substriata*, *Vertigo Baudoni*, *Vertigo acheila*.

## INTRODUCTION

The distribution and ecology of several small land snail species (e.g. the family Vertiginidae) are still poorly known for parts of Europe, especially in the south and south-western areas. This lack of knowledge is partly due to the fact that many of these species, because of their size, are difficult to find. The easiest way to collect them is by sieving of ground-litter, and use of this collecting technique would most probably add much to our knowledge of these small ground living snails.

The latest attempt to sum up the European distribution and present distribution maps for all species was made by Kerney *et al.* (1983: 90-95, 98, 328-329 [maps 51-63]). This book, however, only deals with North, Central and West Europe, hence including France, but not the Iberian Peninsula. For the latter no modern publication treating the entire area exists, although several publications dealing with parts of the peninsula have been published in the latest decades (e.g. Altonaga *et al.* 1994, Bech 1990).

In 1996 I started a revision of the entire material of the genus *Vertigo*, including the large collection of A. Locard, present in the Museum National d'Histoire Naturelle (MNHN) in Paris, in order to get a better understanding of the occurrence and distribution of some of the rarer species in SW Europe. In addition material from this area in the collections in Senckenberg (Frankfurt, Germany), Leiden (the Netherlands) and Cismar [coll. S. G. A. Jaeckel] (Germany) has been revised. The available literature records have also been evaluated and included in the study. The present paper deals only with the four species included in the title. In SW Europe five more representatives of the genus occur: *V. pusilla* (O. F. Müller), *V. antivertigo* (Draparnaud), *V. pygmaea* (Draparnaud), *V. moulinsiana* (Dupuy) and *V. angustior* Jeffreys. These are, however, more widespread and common and will therefore not be treated here.

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## REVIEW OF THE SPECIES

*VERTIGO SUBSTRIATA* (JEFFREYS, 1833) [FIG. 1]

The general distribution picture of the species is characterized as 'boreo-alpine' by Ložek (1964: 204) and Kerney *et al.* (1983: 91; cf. map. 53, p. 328), but according to my opinion North and Middle European is a more proper characterization. As it is mainly a woodland species (although also found in other moist habitats, cf. von Proschwitz 1993: 186-187, 2003: 40-41), its absence or rarity in parts of Central Europe is possibly due to lack of suitable habitats (woodlands with long continuity) (cf. Pokryszko 1990: 178). Its present ecology and available paleontological data give no real evidence for its characterization as a boreo-alpine species (cf. also discussion in Sunier 1926).

The distribution map in Kerney *et al.* (1983: 328, map 53) indicates that *V. substriata* only occurs in a narrow belt in Eastern France close to the border to Germany (Alsace-Lorraine) and Switzerland (Geneve basin). Some scattered old records from this area have been published (Lais 1926: 28 [Woëvre]; Favre 1927: 224 [Geneve area]) and further, more recent finds are given by Colville (1985: 145) and Gaissert (1998: 31, 43, 45, 56). The latter author wrongly states that *V. substriata* is a new species to the Vosgeses. A specimen from a previously unpublished locality in NW France (Eperny, dept. Marne, from coll. M. Staadt) was found in the collection of MNHN, Paris.

*V. substriata* has also been recorded from Massif Centrale (Colville 1985: 145) and in

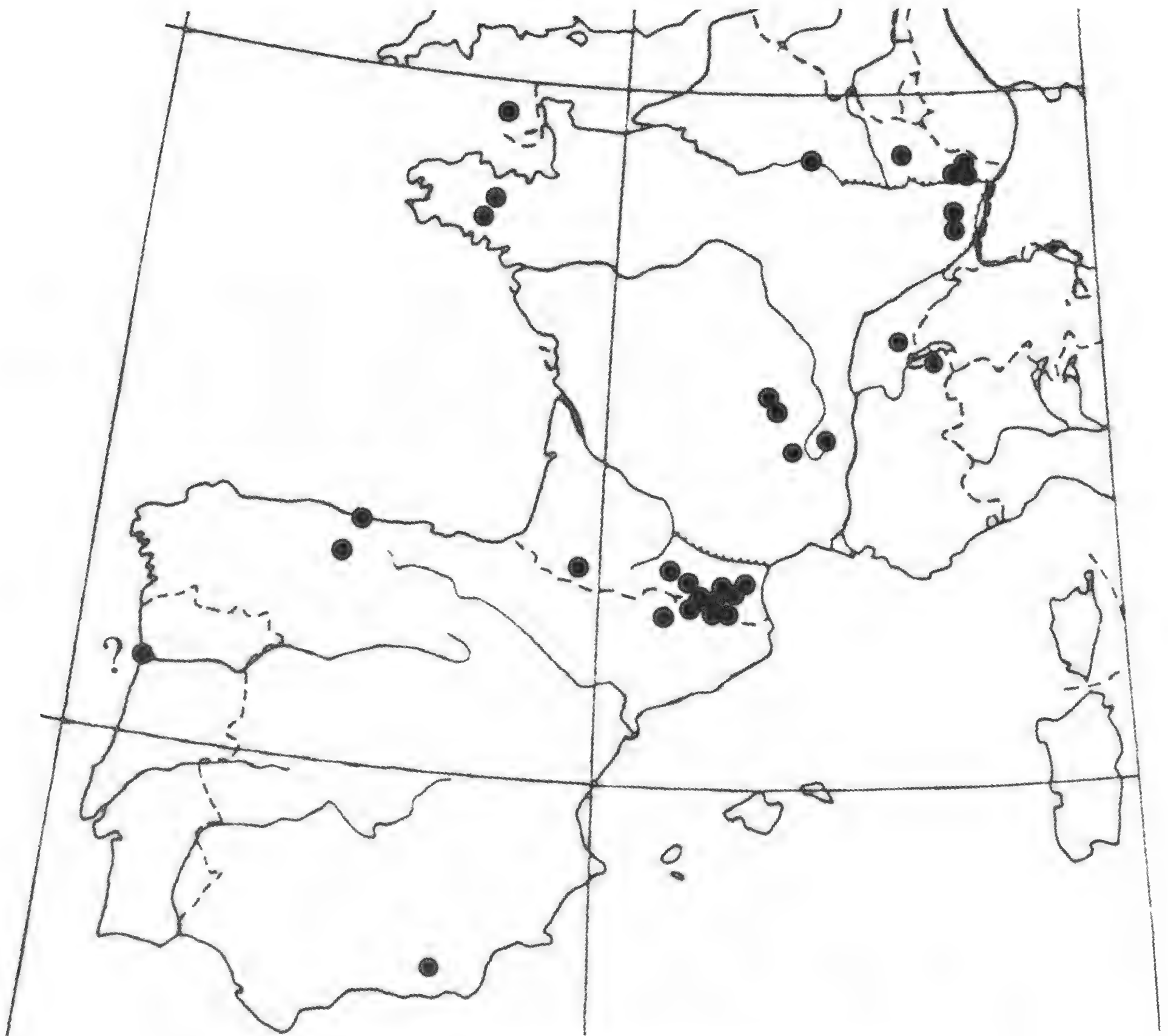


Fig. 1 The distribution of *Vertigo substriata* (Jeffreys) in SW Europe.

this area I found an additional locality in 1995. [Mars at river Lignon, dept. Haute-Loire. In a small boulder-slope close to the mill-ditch]. From western France there are so far only two isolated occurrences in Bretagne (Seddon & Tattersfield 1992: 259). A single record has also been made on the Canal Islands (Guernsey) (Marquand 1913: 91).

*V. substriata* was first recorded in the Pyrenees by van Regteren Altena (1935: 266) and further occurrences are reported by Colville (1985: 145), Raven (1984: 18) and Bertrand (1995: 22, 1997a: 27, 2000a: 45). Altonaga *et al.* (1994: 79, 212: map 44), however, have only summed up some of the older records. The taxon *Vertigo Baudoni*, described from 'le mas de l'Ollastre près de Tautavel' (dept. Pyrénées-Orientales) (Massot 1872: 67, Fig. 6) is, judging from the coarse rib-sculpture mentioned in the description and pictured in the figure, nothing but a form of *V. substriata*. [cf. van Regteren Altena (1935: 266) and the elaborate description in Locard (1894: 333)]. Except for the isolated site at Colda Soulor (dept. Hautes-Pyrénées) (Colville 1985: 145), all other records are from the eastern parts of the mountain ridge (depts. Pyrénées-Orientales, Ariège and Aude). Further records of *V. substriata* also exist from Andorra (Bertrand 1997b: 26, 2000b: 27, Holyoak 2004) and from the Spanish side of the eastern Pyrenees (Viella 1965: 24, Bech 1990: 89). Raven (1984: 17-18) gives two additional isolated localities from NW Spain (Cantabrian Mountains, Oviedo). The latter record is wrongly cited as the first from Spain, cf. Viella (1965: 24) above. A single isolated locality, the species' southernmost, has been found in Sierra Nevada (Grenada, S. Spain) by Seddon & Tattersfield (1992: 259).

The species is published also from Oporto in Portugal (Morelet 1877: 257), a record which has been much doubted and discussed in the literature. Locard (1899: 155) launches the theory that *V. substriata* might have been introduced by ship trade from England, and this is repeated by Altonaga *et al.* (1994: 79). The record has evidently been regarded as so unreliable, that it has been excluded in the Portuguese mollusc fauna by Nobre (1941) and in the latest published check-list of the land and freshwater molluscs of Portugal (Albuquerque de Matos 1994). Jaeckel (1962: 85) states that *V. substriata* has been recorded in S. Portugal, but gives no locality. The origin of this record is puzzling. Neither have I been able to trace any published information, nor is material present in the collection of S. G. A. Jaeckel (Cismar). Maybe there exists confusion with the old record from Oporto published by Morelet (1877: 257).

Even if a large part of the records of *V. substriata* in France is situated in the northern and north-eastern parts of the country (including Massif Centrale) (Fig. 1), there is reason to believe that further field work, with adequate sampling technique, should reveal further records in woodland areas in other parts of France. Ecologically, all the records in the above mentioned areas are of the same character as in other parts of North and Central Europe – *V. substriata* is mainly a woodland species, with a second ecological optimum in rich open fens (cf. von Proschwitz 1993: 186-187, 2003: 40-41).

Geographically, a second bulk of localities is situated in the Pyrenees, and here the occurrences definitely have a mountainous character, as also the finds in the Geneva area have. This is probably the case in the whole southern part of the species' distribution range. In Switzerland this is less pronounced (Turner *et al.* 199: 187), but *V. substriata* is rare or absent in large areas in the south. In Italy it is also mountainous, pronounced northern and very rare. So far it has only been recorded in Alto Adige and the Dolomites (Seddon & Tattersfield 1992: 259, Manganelli *et al.* 1995: 13, 37). Also in the Cantabrian Mountains (Raven 1984: 17) and in the Sierra Nevada (Seddon & Tattersfield 1992: 259) it must be considered mountainous. *V. substriata* has, however, been found also at a lower level in N. Spain (Oviedo) at 300 m.a.s.l., which shows, that it can live also under less mountainous conditions, at least in the precipitation-rich western parts of the Iberian Peninsula. The localities in the Pyrenees (France, Andorra, Spain) are situated in the level 950-2380 m.a.s.l. (van Regteren-Altena 1935: 262, Viella 1965: 24, Raven 1984: 18, Bertrand 1997a: 27, 2000a) and the one in the Cantabrian Mountains

at 1000 m.a.s.l. (Raven 1984: 18), which may indicate that, although not a boreo-alpine species (cf. above), *V. substriata* in periods with colder climate during and after the latest (Weichselian) glaciation, had a wider distribution in SW Europe.

*VERTIGO MODESTA ARCTICA* (WALLENBERG, 1858) [FIG. 2]

*Vertigo modesta* (Say, 1824) is a circumpolar form-group ("Rassenkreis") in which the taxonomical position of several forms and the nomenclature of some of these are far from clear (cf. Pokryszko 1990: 198-200, 2003: 15). The forms from the Carpathians and the Alps have been described as separate (sub-)species *V. modesta zschokkei* Bütikofer, 1920 and *V. modesta tirolensis* (Gredler, 1869) respectively. These do, however, not differ significantly from the Scandinavian form, described from Swedish Lapland, and hence the name for this form, *V. modesta arctica* (Wallenberg, 1858), has priority and should be used for all occurrences in Europe - W. Siberia. In addition to the above mentioned areas the species has also been found at two localities in the Scottish Mountains (Marriot & Marriot 1988: 51, Kerney 1999: 96). The European distribution can be characterized as arctic-alpine.

The first record of *V. modesta arctica* in France was made by van Regteren Altena (1935: 263, 266-267) in the Eastern Pyrenees (Dept. Pyrénées-Orientales, Col du Pam, N of Font-Romeu). More recently it has also been found on the Spanish (Catalonian) side of the Pyrenees (Núria, Ripolles) (Bech & Ramirez 1990:19-20) and in Andorra (SE of Port

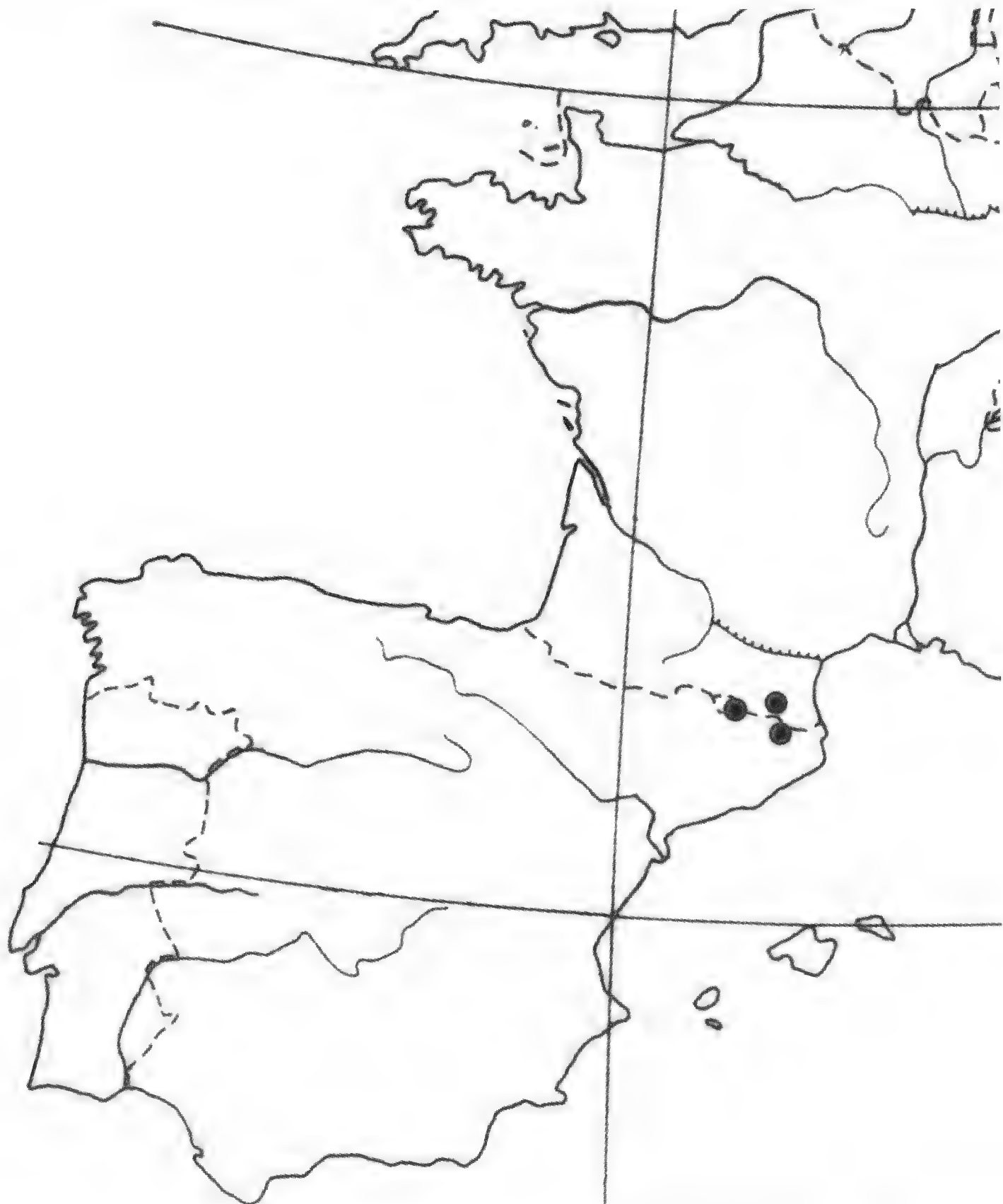


Fig. 2 The distribution of *Vertigo modesta arctica* (Wallenberg) in SW Europe.



d'Envalira) (Holyoak 2004). These three records are so far the only known ones from SW Europe.

The localities are all situated below the tree limit and the altitudes (France: 1900-2000 m.a.s.l, Spain: 2000 m.a.s.l and Andorra: 2150 m.a.s.l.), all lie in the upper part of the species' elevation interval in the Swiss Alps (1600-2160 m.a.s.l. (Turner *et al.* 1999: 192). Contrary to the situation in the Scandinavian mountain ridge, *V. modesta arctica* does not exceed the tree limit in the Pyrenees or in the Swiss Alps. In the south of Norway it has been found at 1470 m.a.s.l. in the *regio alpina* (von Proschwitz 2003: 36). The habitats for the three Pyrenean sites differ somewhat ecologically: Andorra: Herb-rich wet grass-land (Holyoak 2004), Spain: Humid, shrubby places with stones (Bech & Ramirez 1990: 19-20), France: Under debris close to a stream, covered by *Saxifraga* (van Regteren Altena 1935: 266-267). In Scotland it is found on ledges with scrubs and short turf (Kerney 199: 96) and in Switzerland on the banks of brooks and in marshy alpine carpet-vegetation (Turner *et al.* 1999: 192). The overall picture of all these, rather few scattered occurrences, seems somewhat heterogeneous, but they all fall into the range of or are similar to habitats inhabited in the main European distribution area in the Scandinavian mountain ridge. Here it is a typical species in the sub-alpine birch forests and it also occurs regularly in the *regio alpina*, especially in valleys with *Salix*-shrubs, but also among tall herbs, in carpets of *Dryas* and in rich and medium-rich fens (von Proschwitz 2003: 36).



Fig. 3 The distribution of *Vertigo lilljeborgi* (Westerlund) in SW Europe.

*VERTIGO LILLJEBORGI* (WESTERLUND, 1871) [FIG. 3]

This species can be characterized as North European, as the bulk of its localities are situated in Scandinavia and the northern and western parts of the British Isles (cf. Kerney *et al.* 1983: 94, 329: map 59, von Proschwitz 1992: 197). Outside this continuous distribution area *V. lilljeborgi* has a few scattered occurrences in southern Germany: Bayern (Hässlein 1964) and Baden-Württemberg (Gerber 1987). In these sites it can be regarded as a glacial relict.

The only published record for France and the Pyrenees is from the same area as that of *V. modesta arctica*, dealt with above (dept. Pyrénées-Orientales, near Font-Romeu) (van Regteren Altena 1934: 262, 265-266). During the revision of the material in coll. S. G. A. Jaeckel (Cismar) a so far unpublished second record of *V. lilljeborgi* from the same parts of the Pyrenees, but from the Spanish side (first record from Spain) was detected: Catalonia, La Junquera (leg: S. G. A. Jaeckel 1960). The elevation of this locality is not known, however, it is situated in the mountainous area and the habitat is a marsh with puddles. At Font-Romeu the locality is situated at 1800 m.a.s.l. in marsh-meadows with scattered trees. *V. lilljeborgi* was accompanied by several other hygrophilous snail species (van Regteren Altena 1935: 262-263). In Scandinavia and on the British Isles *V. lilljeborgi* occurs in open oligo-mesotrophic marshes, fens and in shore-zones of lakes and streams of the same character (von Proschwitz 1993: 196, 2003: 35, Kerney 1999: 97). In these aspects, the character of the Pyrenean sites agrees well with the circumstances under which the species occurs in Scandinavia. Due to the climatic requirements of *V. lilljeborgi*, however, occurrences outside the high mountainous areas seem extremely unlikely in southern Europe. The very high nature conservation value for these isolated southern relict occurrences should be stressed.

*VERTIGO ALPESTRIS* ALDER, 1838 [FIG. 4]

The species' general distribution is characterized as Nordic-alpine by Kerney *et al.* (1983: 98, 329: map 62) and as boreal-alpine by Pokryszko (1990: 196). This is, however, in my opinion, as in the case of *V. substriata* not a correct classification. *V. alpestris* is distributed throughout the Scandinavian Peninsula, and here it shows no preference for higher altitudes or alpine habitats. It is mainly a woodland species with a special preference for boulder habitats (von Proschwitz 1993: 192-193, 2003: 29-30). Nor is the characterization as alpine adequate for Germany (cf. distribution map in Kerney *et al.* 1983: 329: map 62) and it should be noted that in Switzerland, although here predominantly found in alpine habitats, it is recorded down to 270 m.a.s.l. (Turner *et al.* 1999: 195). Hence, in accordance with these facts I suggest that a zoogeographical classification of *V. alpestris* as North- and Middle European is more adequate. As in the case of *V. substriata*, the absence of *V. alpestris* in large areas may mainly be due to the destruction or alteration of suitable habitats by man in historic time.

The distribution in France is marked only as a narrow belt in the north-eastern part (Alsace) in Kerney *et al.* 1983: 98, 329: map 62). As in the case of *V. substriata* the compilation of literature data and the revision of museum material have shown that *V. alpestris* has a wider distribution in France. From Alsace (Vosgesen) several records are known (Andreae 1879: 94, Gaissert 1960: 187, 1997: 50, 62, 1998: 31, 43, Colville 1985: 145). From N. France *V. alpestris* has been found in debris material from Brune (Prives) (dept. Aisne) by Steusloff (1924: 117, 119) and there exists an unpublished record from the Paris area (Argenteuil, coll. Locard). There are also records from the eastern part of central France: Klemm (1943: 100-101) reports it (recent and debris) from dept. Yonne and in the Paris museum unpublished material of *V. alpestris* is also present from a locality in dept. Nièvre (Canne, at Moulin de Goulineau, origin unknown). Totally four records are known from Massif Centrale: Colville (1985: 145) gives two localities, unpublished material from one locality is present in the MNHN, Paris (Vic-sur-Cère, dept. Tarn) and

finally I found it in dept. Haute-Loire at Mars at river Lignon in 1995, together with *V. substriata* (cf. above).

*V. alpestris* is also reported in debris material of the river Rhône, north of Lyon [as *Vertigo shuttleworthiana* (Charpentier)] by Locard (1882: 179) (first published record from France). Also Caziot & Margier (1920: 373) report the species in debris of the river Rhône, without giving any exact localities.

In the collection of S. G. A. Jaeckel (Cismar) there is an unpublished sample from Mount Blanc close to the Swiss border. A further sample in the same collection from the western Pyrenees (Biarritz, dept. Basses-Pyrénées) consists actually of *V. pygmaea*. Recently, however, a record was made in SE France (dept. Alpes-de-Haute-Provence, Montagne de Lure) (Gargominy 2002: 537). The southern outpost of *V. alpestris* in this area, which is situated at 800-1826 m.a.s.l. (Gargominy 2002: 536) in the Mediterranean part of France, has a clear mountainous character (cf. the isolated occurrence of *V. substriata* in Sierra Nevada above).

At the present state of knowledge *V. alpestris* must be considered a mainly eastern-central element in France, so far not found in the Pyrenees and with only one known (mountainous) occurrence in Mediterranean area. The species is fairly spread in Switzerland (Turner *et al.* 199: 195), but in Italy it is only found in the northern part (Manganelli *et al.* 1995: 13).

So far there are no records of *V. alpestris* from the Iberian Peninsula. Haas (1924: 155,

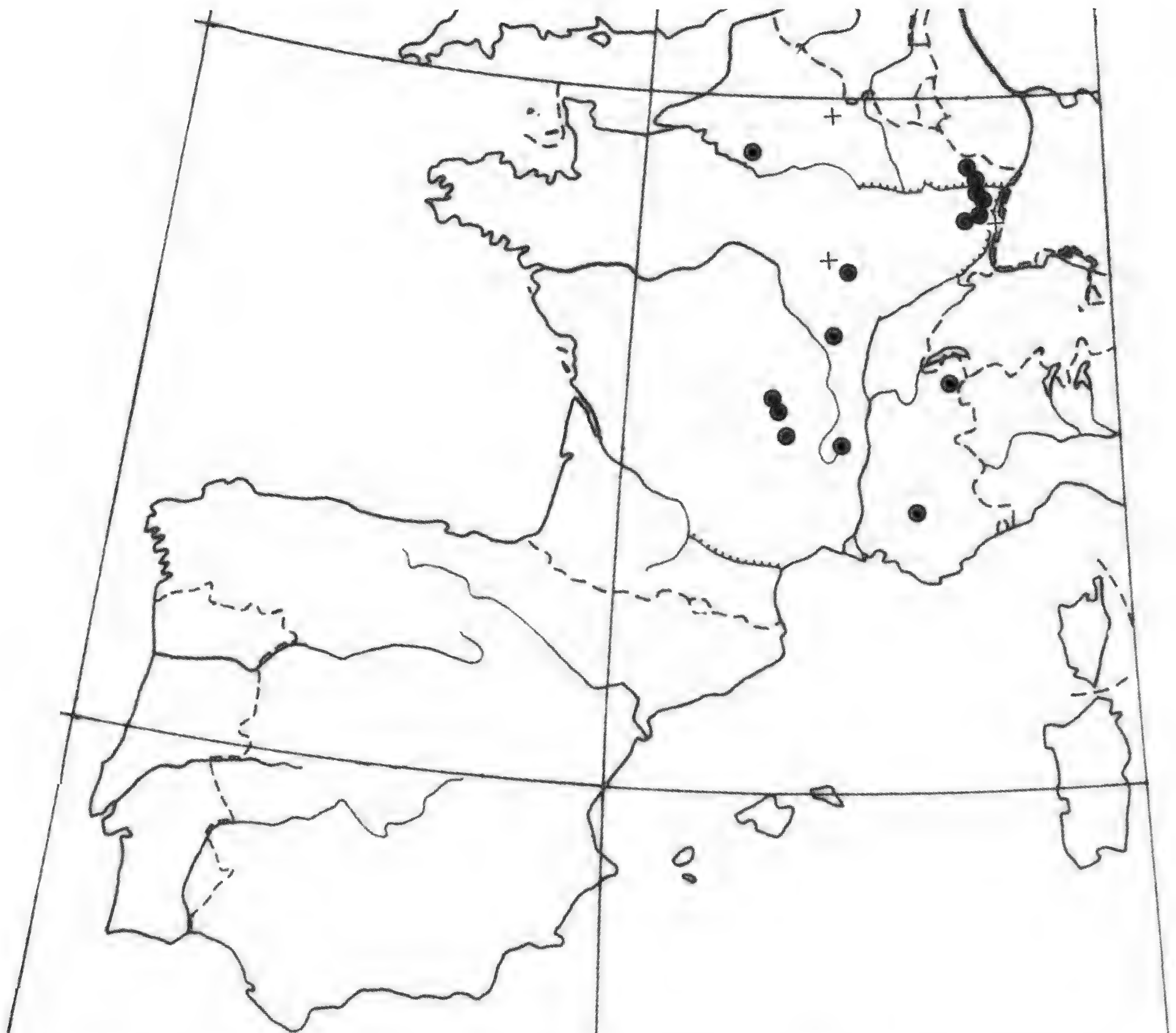


Fig. 4 The distribution of *Vertigo alpestris* Alder in SW Europe. + = debris records.



Taf. VIII (8-8a) reports *Vertigo acheila* Servain from debris material of the River Ebro, at Flix (Prov. Tarragona, Catalonia) and considers it a form of *V. alpestris* (*V. alpestris acheila*). Geyer (1925: 102) shows that this is incorrect and is of the opinion that it is a form of *V. moulinsiana*. This view is discussed and accepted by Haas (1925: 235). According to the original description by Servain (1880: 125-126) and to the figure in Haas (1924), which very clearly shows the characteristic pronounced transverse external rib close to the aperture, it is, however, without doubt a form of *V. pygmaea*. Hence, the name *V. acheila* should be placed in the synonymy of that species.

### ACKNOWLEDGEMENTS

I am very grateful to Prof. P. Bouchet (Paris), Prof. E. Gittenberger (Leiden), Dr. R. Jansen (Frankfurt am Main) and Dr. V. Wiese (Cismar) for loan of material from the museum collections. My best thanks also to my colleagues and friends G. and M. Falkner (München) for valuable advice and help concerning literature. T. Nordander (Göteborg) made the final version of the figures and assisted me in many ways during the preparation of the manuscript. The completion of this work was made possible by a PARSYST research grant (ERB EMGE-CT98-0132) from Muséum National d'Histoire Naturelle, Paris and a research grant for senior museum curators from The Royal Society of Arts and Sciences in Göteborg (KVVS).

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## ADDENDUM

Since the submission of the manuscript the following additional records of *Vertigo substriata* from France have come to my knowledge:

Bertrand (2004: 34) gives one record from dept. Cotes d'Armor and two from dept. Pyrénées-Orientales; (Cucherat 2003: 60) mentions three records from the region Nord-Pas-de-Calais. The new sites in the Pyrenees and in Bretagne are situated in areas there the species seem to be rather spread (cf. Fig. 1). The localities in the region Nord-Pais-de-Calais fill a gap in the north-westernmost part of France there the species is supposedly more spread.

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# PATTERNS OF SHELL DAMAGE AMONG SNAILS FROM A COPPICE WOODLAND IN SUSSEX, ENGLAND

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*Abstract* Snail shells from a coppiced, ancient woodland were examined quantitatively for signs of damage. Six distinct patterns of damage were found. One type of damage was believed to be inflicted during predation by a snail *Aegopinella nitidula*, preferentially attacking its own species, another was believed to be caused by beetle predation. These two predators accounted for 42% of the damage observed and 17% of mortality. The relationships between type of damage, maturity of snail and time since coppicing are examined. Species preferences by the predators are also analysed and possible effects on the population. Only one species, *Discus rotundatus*, which has pronounced ribs on the shell, showed evidence of survival and shell repair and possible evolutionary implications are discussed.

*Key words* Snail, coppice woodland, shell damage, beetle, predation

## INTRODUCTION

Snail shells can survive for months to years after the animal has died, depending upon the environment. From the number of whorls present, the shells can give an indication of the approximate age of the animal at death (Kerney & Cameron, 1979; Millar & Waite, 1999) and from the marks left on the shell, the mode of death can be determined for some (Mordan, 1977). Some predators break the shell open in a characteristic way enabling the predator to be identified. Others crush the shell when eating either in their mouth or gizzard/stomach and very little of the shell remains, others remove the body and leave the shell undamaged.

While much work has been published on the importance of land snails as prey items to various terrestrial predators, with the exception of Mordan (1977) little has been published on the extent and potential impact of predation on snail populations in the UK. Some work has been carried out on the effect of predators on snail populations in other countries; Canada (Digweed, 1993); Greece (Schilthuizen, Kemperman & Gittenberger, 1994; Welter-Schultes, 2000); Israel (Shachak, Safriel & Hunum, 1981); Tanzania, (Kasigwa, Mrema & Allen, 1983); Turkey (Orstan, 1999); U.S.A. (Quensen & Woodruff, 1997). In the present study snail shells were collected from a coppiced woodland in southern England and examined for signs of damage. The nature and pattern of shell damage is described and certain types related to possible predator attacks. Relationships between the nature and extent of apparent predator attacks, snail species and habitat conditions are considered.

## SITE DESCRIPTION AND DATA COLLECTION

West Dean Woods Nature Reserve, West Sussex (Grid Reference SU845155) is a small (16.6 hectare) semi-natural, deciduous woodland owned by the Edward James Foundation and leased to and managed by the Sussex Wildlife Trust since 1975. This SSSI woodland is on a gentle south-facing slope of the South Downs. Although on the Chalk of the Upper Cretaceous the site is overlain by Head deposits which vary in thickness over the site and the soil pH is generally less than 7.0. The vegetation is predominantly oak and hazel woodland, with bluebells and conforms to the National

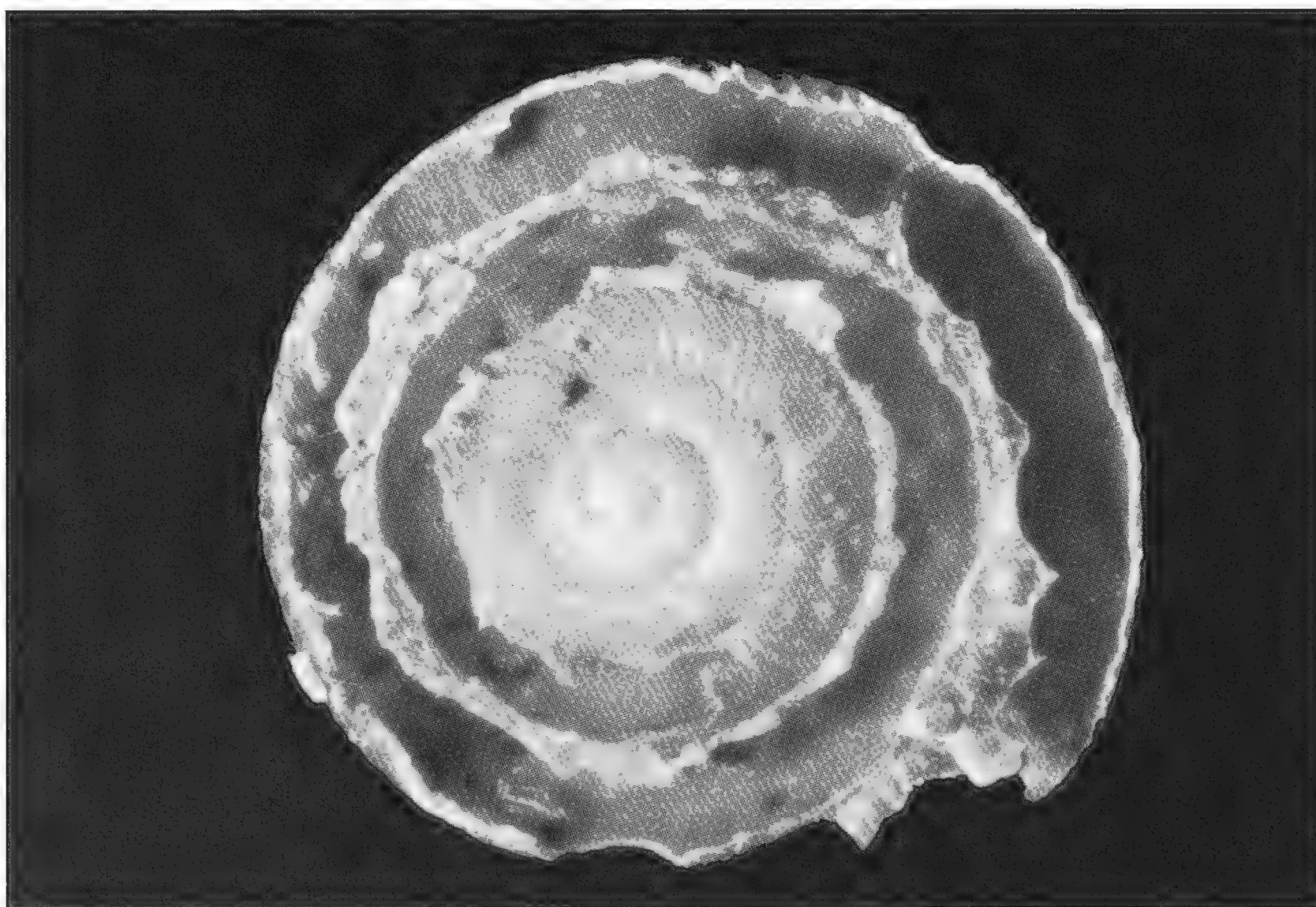
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Vegetation Classification woodland type W10 (Rodwell, 1991). The woodland is divided into compartments that are coppiced on an 11 to 15 year cycle. Top soil and leaf litter were collected to a depth of approximately 4 cm from four randomly placed quadrats (0.5 x 0.5m) placed in each of 12 coppiced woodland compartments. The time from the last cut varied between the sampled compartments from one year, where the coppiced hazel had been cut the previous winter, to a compartment that had last been cut 12 years before. For comparison, samples were also taken from two large control areas which had not been coppiced for over 40 years; one was an open grassy area with standing oaks (*Quercus robur* Linnaeus), the other an overgrown coppice tending towards closed mature woodland in structure.

Samples were collected over a 4 week period during May/June 1996. They were oven dried, sieved and the snail shells and fragments were extracted, sorted and counted. The shells were divided into adult or juvenile. Adult shells in this study were defined as those possessing the characteristic lip modification achieved on maturity by determinate species such as *Carychium tridentatum* (Risso), *Clausilia bidentata* (Ström) and *Cochlodina laminata* (Montagu). Those species which do not modify their lip were considered adult if they possessed more than five-sixths of their potential number of whorls (as given in Kerney & Cameron, 1979). In each category the snails were scored as alive or dead at the time of collection. All the empty shells were considered to be 'fairly fresh', i.e. from recently dead snails, with most of the organic periostracum still present. Following Evans (1972) and Cameron & Morgan-Huws (1975) who believed the periostracum to be lost within a year or so of death, these were classified as a year or less old. This means that damage and mortality figures might reasonably be expected to represent the last 12 months and should not be unduly influenced by, for example, invertebrate predators only active for a few weeks in the year or at the time of collection. All dead shells were carefully examined, any signs of damage were described and the nature of damage noted.

Further details on the site, the sampling regime and of the snail communities present are given in Millar & Waite (1999, 2002). The species nomenclature used is that given by Waldén (1976).



**Figure 1** Photograph of adult *Discus rotundatus* with damage type 1. Shell diameter 6mm.





**Figure 2** Photograph of adult *Discus rotundatus* which had survived a beetle attack (type 1) on final whorl and which had subsequently repaired its shell with 'atypical' shell material, thereafter growing and increasing its whorls with typical shell. Note minor apertural damage leaving scar after growth arrests on whorls 3 and 4. Shell diameter 6mm.

## DATA ANALYSIS

Difference between compartments and among species of snail in terms of the prevalence of their abundance, and the extent of different types of shell damage were tested for significance using the  $\chi^2$  procedure (Sokal & Rohlf, 1995), supplemented by simple correspondence analysis (Minitab, 1995). Species and compartment ordinations were performed using principle component analysis following the procedures outlined in Waite (2000). These ordinations allow the spectrum of predator shell damage shown by the different species of snails present in the different woodland compartments to be compared. All statistical analysis was performed using MINITAB version 13.31. The gradients in community turnover, as assessed from the similarity in species composition between compartments, did not warrant the use of detrended correspondence analysis (James & McCulloch, 1990; Waite, 2000). Because of the highly variable counts obtained between quadrats within sample compartments, pool values were used in the analysis.

## RESULTS

### TYPES OF SHELL DAMAGE IDENTIFIED

Of the total snails extracted from the samples 62.6% were dead on collection. Of these 39.4% (2189 shells) had clear signs of damage. In the majority of cases only one type of damage was found on individual shells. With the exception of *C. tridentatum* it was possible to characterise the damage evident on all shells for the 25 species of snails found in the samples into six distinct categories (Table 1).

Type 1. Starting at the apertural lip, the whorl of the shell was removed leaving the





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septum, cleanly broken edges and a skeletal appearance. This pattern of damage was only noticed on shells less than about 6mm in diameter, but was found on both flat spired and high spired species. When evident on a flat shelled species it was more frequently found on the upper surface. (Figures 1, 2 and 3.)

Type 2. Marks consistent with a general gnawing or grazing through the periostracum and shell, leaving holes of varying sizes from less than one, to several millimetres.

Type 3. Presence of cleanly broken edges, with no regular pattern, often occurring in first whorl or with jagged breaks around the aperture or loss of all whorls on one side. (Figure 4)

Type 4. Presence of a moderate to large sized (relative to the shell) rasped hole about three quarters of the way round the first whorl from the opening and usually on the underside. (Figure 5 and 6)

Type 5. Removal of calcareous part of the shell leaving the organic periostracum layer.

TABLE 2

Frequency of Damage Types 1 to 4 among the most abundant snail species present in combined data sets. Rows labelled O contain observed values, rows labelled E contain expected values calculated using MINITAB version 13, and assume that the distributions of damage types and species are independent of each other.

Species		Type of shell Damage				Residual row $\chi^2$ values
		Type 1	Type 2	Type 3	Type 4	
<i>Carychium tridentatum</i>	O	101	491	1	44	294.47
	E	207.29	281.20	70.82	77.69	
<i>Cochlicopa lubrica</i>	O	59	34	38	7	55.52
	E	44.91	60.92	15.34	16.83	
<i>Discus rotundatus</i>	O	216	97	32	21	119.00
	E	119.10	161.57	40.69	44.64	
<i>Vitrea contracta</i>	O	15	35	22	12	23.15
	E	27.34	37.08	9.34	10.25	
<i>Nesovitrea hammonis</i>	O	13	15	8	11	8.25
	E	15.29	20.75	5.23	5.73	
<i>Aegopinella pura</i>	O	61	43	26	29	20.87
	E	51.74	70.19	17.68	19.39	
<i>Aegopinella nitidula</i>	O	84	62	48	74	90.26
	E	87.21	118.31	29.79	32.69	
<i>Oxychilus cellarius</i>	O	54	41	31	28	26.78
	E	50.11	67.98	17.12	18.72	
					Total	638.322
Overall $\chi^2$ value for table = 638.322, df = 21, p < 0.0001						





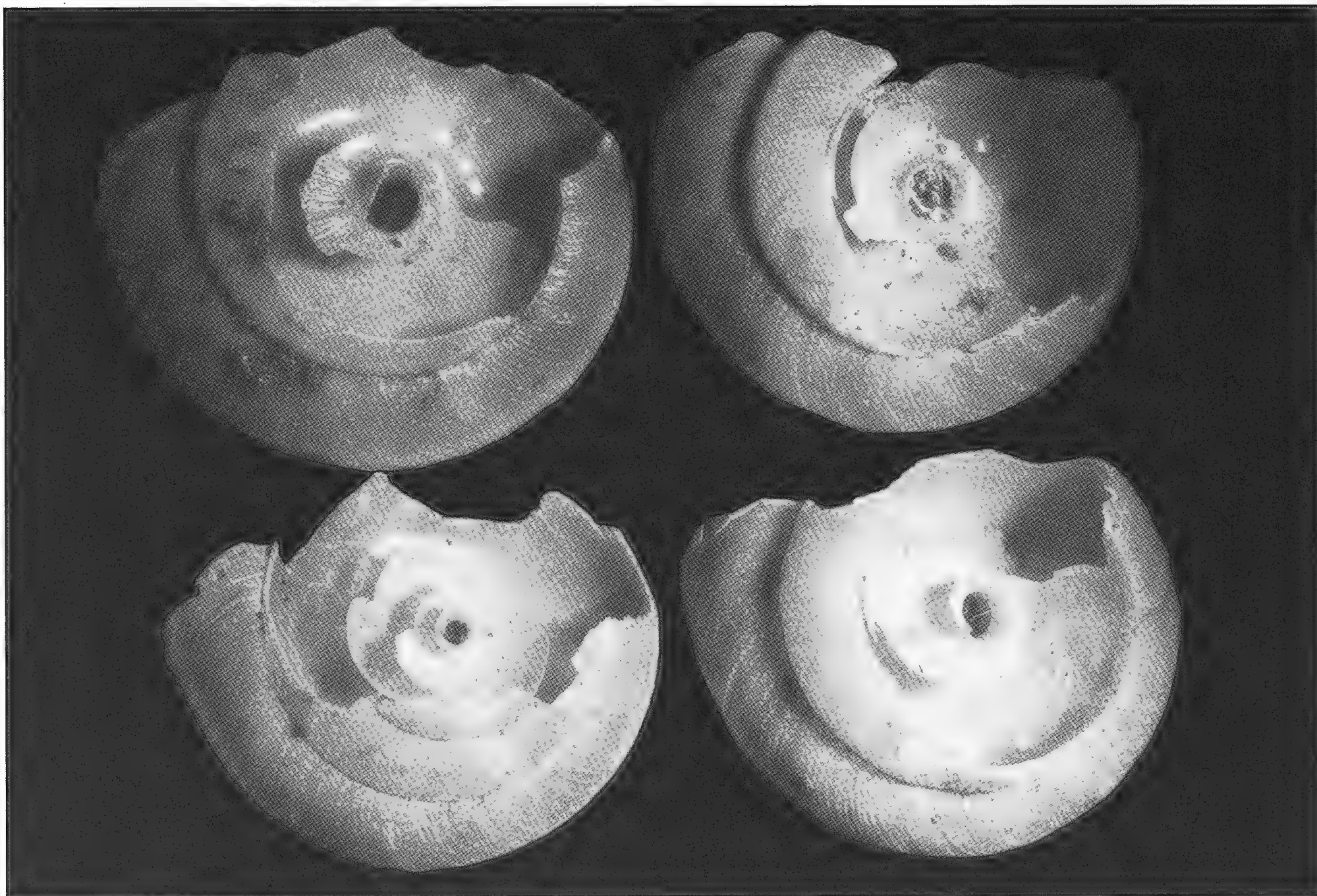
**Figure 3** Photograph of juvenile *Aegopinella nitidula* with fatal type 1 beetle attack. Shell diameter 5mm.

Since periostracum layer is generally short-lived and not likely to persist longer than a year (Evans 1972) this type of damage must have occurred on a freshly dead shell. Mostly found on *Discus rotundatus* (Müller), *Oxychilus cellarius* (Müller) and *Acanthinula aculeata* (Müller). (Figure 7)

#### Type 6. Crushed and flattened shell.

No borderline cases were found; all the damage types were quite distinctive for all species except *C. tridentatum*. In the case of *C. tridentatum*, 642 empty shells were found with clear evidence of damage. For 70 adult and 31 juvenile shells the damage clearly conformed to type 1, while 40 adult and 4 juvenile shells had type 4 damage. Of the remaining damaged shells the majority showed patterns of damage most consistent with type 2, but with either the removal of the top or bottom of the shell. Only 60 shells demonstrated the typical pattern of type 2 damage with grazed holes being evident, in most cases the extent of damage was considerably greater. The protoconch/top whorl had been removed from 130 adult and 15 juvenile shells; the top half the shell was removed, leaving the bottom whorl intact, from 132 adult and 6 juvenile shells. The basal whorl was removed from 148 shells. As 84% of the live *C. tridentatum* are adult and as many of the shell remains possessed 4 whorls out of a possible 5 in the adult, these were counted as adult for convenience.

The overall frequency of damage types and their occurrence among the shells of different species of snail are given in Table 1. Type 5 and type 6 damage were rarely encountered; occurring on only 52 shells. With the exception of *C. tridentatum* and *Punctum pygmaeum* (Draparnaud), damage was most frequently evident on juvenile shells. Of the more commonly found species, most incurred damage of between 27% and 40% of the total dead snails found. Four species (*D. rotundatus*, *Nesovitrea hammonis* (Ström), *A. nitidula*, *Oxychilus* sp.) incurred a greater proportion of damage (over 50%) (See Table 1). The mean frequency of shell damage was 34%. The frequency of shell

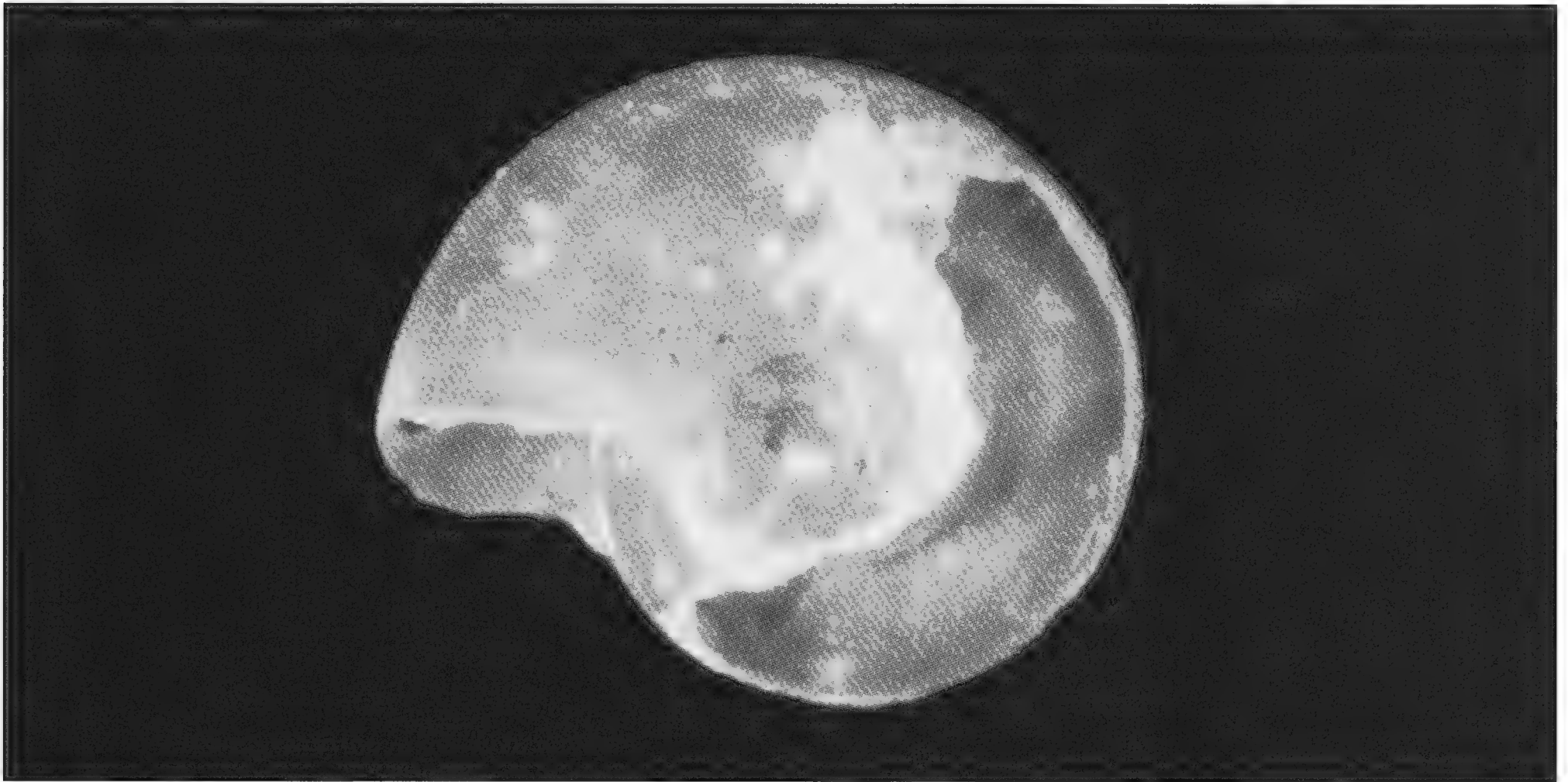


**Figure 4** Photograph of type 3 breakage. In this case small mammal damage on *Trichia striolata* from the edge of a bridle path. Shell diameter 10mm.

damage types 1 to 4 differed significantly among and between the 8 most abundant species (Table 2).

It is clear from Table 2 that significant associations exist between damage types and snail species. From consideration of cell residuals (Sokal & Rohlf, 1995) and the differences between observed and expected values it is evident that distinct and contrasting patterns of shell damage occur among the species. Disproportionately high rates of Type 1 damage occurred among the shells of *D. rotundatus*, while shells of *Cochlicopa lubrica* (Müller), *V. contracta*, *A. nitidula* and *O. cellarius* all show substantially higher than expected rates of Type 3 damage. Type 2 damage was concentrated among shells of *C. tridentatum*, this species also had much lower than expected rates of Type 3 damage. Type 4 damage was over represented among shell of *A. nitidula* and under represented among shells of *C. tridentatum* and *D. rotundatus*. By applying simple correspondence analysis (Manly, 1994; Minitab, 1995) a weighted principal component analysis of the contingency table was performed. This aids the interpretation of the result of the  $\chi^2$  analysis (Minitab, 1995) by allowing a combined ordination of damage types and species to be produced (Figure 8). Approximately 72% of the total inertia (i.e., variation in  $\chi^2$ ) is accounted for by the first component, the second component accounts for 21.6%. From the ordination it is clear that damage patterns associated with *N. hammonis*, *A. nitidula*, *V. contracta* and to a lesser extent *O. cellarius* and *Aegopinella pura* (Alder) are similar, and differ substantially from those shown by *C. lubrica*, *D. rotundatus* and *C. tridentatum* (Figure 8).





**Figure 5** Photograph of type 4 damage, caused by *Aegopinella nitidula*, on *Aegopinella pura*. Shell diameter approximately 3mm.

#### PREVALENCE OF SHELL DAMAGE TYPES AMONG SAMPLES

Where sufficient shells were available it was possible to compare statistically the patterns of damage shown by adult and juvenile snails of the same species. In these comparisons data for damage types 3, 5 and 6 were removed to ensure adequate samples size in each expected cell. Significant differences were evident among adult and juvenile snails for *C. tridentatum* ( $\chi^2$  56.71, df=2,  $p \leq 0.001$ ), *C. lubrica* ( $\chi^2$  7.09, df=2,  $p \leq 0.05$ ) and *D. rotundatus* ( $\chi^2$  66.06, df=2,  $p \leq 0.001$ ). If the figures for *C. tridentatum* are removed for each damage type juveniles account for between 73% and 91% of the damaged shells

Type 1. A total of 15 of the 25 species found in the quadrats showed this damage. (Figures 1, 2 and 3). A total of 87% of this damage was found on the shells of only 6 species (78% of total shells). Five times more juvenile shells showed this type of damage than adults (538 to 121) and ten times as many if *C. tridentatum* are excluded (507 to 51). (Figure 8). The principal species affected are shown in Table 1. It is clear that type 1 damage is a major cause of mortality for juvenile snails with 36% of the dead juvenile *D. rotundatus* showing type 1 damage, and for adults of *A. pura*, where 17% of recovered adult shells had type 1 damage.

The damage was typically present on the upper side of the shell. Only on three *D. rotundatus* dead shells was damage found on the underside of the shell. Evidence that the snails had been alive when attacked was found. Some *D. rotundatus* shells with type 1 damage were found with body remains inside.

Type 2 damage was the most frequently encountered form of shell damage, being found on 41% of damaged shells. It was the only damage type where a higher proportion of adults were damaged than juveniles; of the 908 shells found with type 2 damage, 63.3% were adults, but this was mostly due to *C. tridentatum* which if removed results in 73% of damaged shells being juvenile. Shells of 19 out of the 25 species found showed type 2 damage characterised by grazing marks on and through the shell. No trace of repair was found associated with this type of damage.



Type 3. This form of damage, was found on the shells of 19 species. Overall it accounted for approximately 13% of damaged shells and was considerably more common on juvenile shells (Table 1). Among the juvenile shells showing this type of damage 20% were *A. nitidula*, 13% were *C. lubrica*, 12% were *D. rotundatus*, 12% *O. cellarius*/sp. and 10% *A. pura*. Among the adult shells showing this damage 12% were *C. lubrica*, 10% were *P. pygmaeum*, and 9% were *Trichia hispida* (Linnaeus).

Type 4 The juvenile shells of 15 species, and adult shells of 11 species showed evidence of type 4 damage (Table 1). Of the 268 shells showing the damage, the highest number; 74 (27.6%), were found on shells of *A. nitidula*. The species most frequently showing type 4 damage were not the most abundant species.

#### COMPARISON BETWEEN THE PATTERNS OF DAMAGE SHOWN BY MORE COMMON SPECIES

Type 1 damage was the principal form of damage for *E. fulvus*, *D. rotundatus*, *C. lubrica*, *A. pura*, *A. aculeata*, *O. cellarius*/sp. and *A. nitidula*. Type 2 was the most common for *C. tridentatum*, *A. fusca*, *Vitrea contracta* and *N. hammonis*. Type 3 was the main form of damage for *Vitrina pellucida* (Müller) (probably because it is such a fragile shell) *T. hispida* and *Cepaea* sp. Type 4 was the most common form for *P. elegans* and *P. pygmaeum* and next most important for *A. nitidula*.

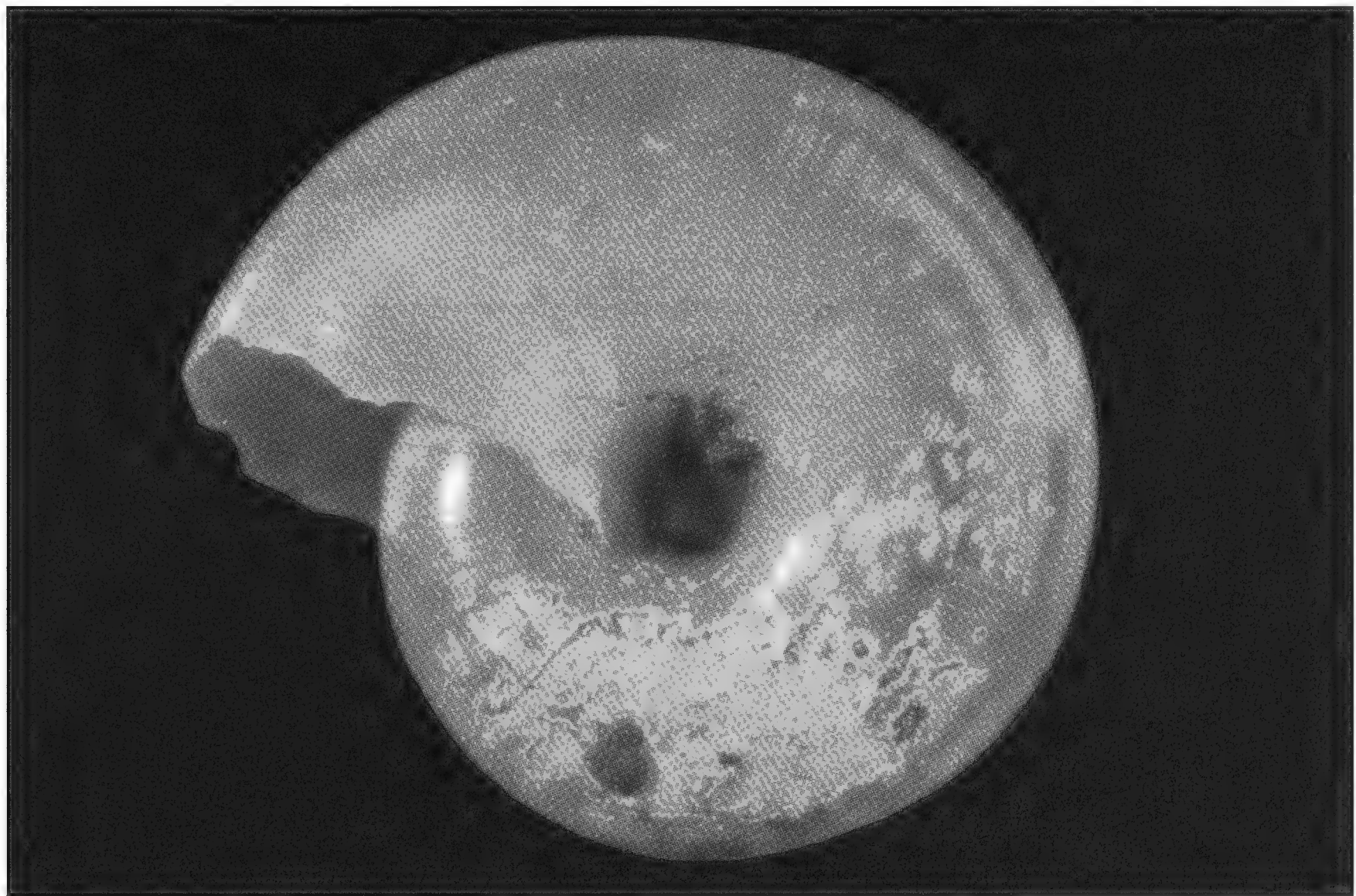
An ordination of species based on their patterns of shell damage (types 1 to 6) for juvenile and adult shells of the eight most abundant species is presented in Figure 9. The first two axes accounted for 85% of the variation present in the data set. The closeness between plotted points in the ordination diagram reflects the degree of similarity in the patterns of shell damage shown. The majority of species, both adult and juvenile demonstrate a similar spectrum of damage types, tending to cluster in the bottom right hand quadrant of the ordination. Some adults of *C. tridentatum*, and juvenile shells of *D. rotundatus*, *A. nitidula* and *O. cellarius* occur as outlying points indicating that the pattern of shell damage experienced by these species differs substantially.

#### DAMAGE IN RELATION TO COMPARTMENT AGE

Compartments 8, 10, 11 and 40+ years since time of coppicing showed the highest proportion of damage of all types with 61% to 63% of total shells (all species) damaged. (Table 4) The greatest numbers of damaged shells were found in 9yrs and 7yrs. There was a different trend for the proportion of type 1 damage among adult and juvenile snails. Among juveniles the proportion of type 1 damage was highest among samples collected from compartments aged 5 and 6 years. In contrast the highest proportions of type 1 damage were evident on adult shells from compartments aged 3 to 4 years and 9 to 10 years. When *C. tridentatum*, (being the most abundant and somewhat anomalous to the other species in terms of damage), were removed no significant difference was observed between adult and juvenile damage.

The overall frequencies of shell damage types 1 to 4 for all juvenile shells ( $\chi^2$  160.57, df = 18,  $p \leq 0.001$ ) and adult snails ( $\chi^2$  32.38, df = 18,  $p \leq 0.01$ ) differed significantly between woodland compartments of different ages. When adult and juvenile shells are combined for the six most abundant species, the overall frequency of damage types 1 to 4 differed significantly ( $\chi^2$  79.65, df = 10,  $p \leq 0.001$ ) with compartment age when grouped (to avoid low cell counts) into three age classes 1 to 4, 5 to 8 and 9 to 12 years from the last episode of coppicing.

Type 4 damage accounted for the highest proportion of damage in compartments 8, 10, 11 yrs, with highest numbers in years 9, 6 and 7. There does not seem to be a clear relationship between the numbers of type 4 shells and abundance of *A. nitidula*, the presumed predator (figure 10). Any relationship between type 4 damage and species abundance will be complicated by the apparent preference of this predator for its own species.



**Figure 6** Photograph of attempted attack by *Aegopinella nitidula* (type 4) on *A. pura*. Shell diameter approximately 3mm.

## DISCUSSION

### DAMAGE TYPES

**Type 1.** Type 1 damage is considered to be caused by one (or more) species of predator using one particular technique. Harvestmen and spiders are known to be predators of snails and slugs (Nyffeler & Symondson, 2001). The spiders are not known to damage the shell, nor are short-legged Trogulidae harvestmen. However, although not currently found in the UK, the European species of harvestman *Ischyropsalis hellwigi* (Panzer) (Ischyropsalididae) has chelicerae strong enough to break the shell starting from the aperture. This *I. hellwigi* breakage, as illustrated by Martens (1965), looks superficially similar to the type 1 damage but larger fragments of shell are broken away in a less regular way than the pattern found in this study.

It is possible that shrews attack snail shells in a fashion likely to cause damage similar to type 1. If this were the case then they would have used their lower jaw inside the shell and pushed up to break the shell as the fragments were peeled back and held by the periostracum layer on the outside (see Figure 1). Measurement of the width of the lower front teeth of three skull specimens of common shrew (*Sorex araneus*, Linnaeus) were between 0.89mm and 1.37mm and for Pygmy shrew (*Sorex minutus*, Linnaeus) two specimens were 0.81mm. The width of damage of type 1 varies from 0.38mm to 0.56mm for *D. rotundatus*, 0.4mm for *P. pygmaeum*, 0.76mm to 0.81 for *A. pura* and *A. nitidula* and 0.2mm to 0.3mm for *C. tridentatum*. While there is little doubt that shrews eat snails (e.g. Whitaker & French, 1984), on dimensional grounds it seems unlikely that any of the damage observed as type 1 is caused by shrews.

The most likely candidate causing type 1 damage in the present study is a beetle; probably as adult rather than larva. Certain members of the beetle families Carabidae and Staphylinidae include specialist hunters of snails as adults (El-Moursy & Ball, 1959; Sturani, 1962; Stephenson, 1968; Crowson, 1986; Brandmayr & Zetto Brandmayr, 1986; Digweed, 1993). Sturani (1962) describes a beetle group which has a well developed



TABLE 3  
Relative abundance of two species at three different sites.

	Monks Wood	Wytham	West Dean
<i>Nesovitrea hammonis</i>	1.6/m <sup>2</sup>	0.5/m <sup>2</sup>	5.1/m <sup>2</sup>
<i>Aegopinella nitidula</i>	13.6/m <sup>2</sup>	7.9/m <sup>2</sup>	17.4/m <sup>2</sup>
Ratio of A to N	8.5	15.8	3.4

fore-body and strong jaws for ripping open the shell and the damage he describes, inflicted on snails by *Carabus coriaceus* (Linnaeus), appears to be identical to the type 1 damage recorded in the present study. Very similar damage is illustrated by Brandmayr & Zetto Brandmayr (1986) caused by Licinini beetles such as *Licinus italicus*.

All the insects extracted from the oven dried sieved samples were examined and several specimens of *Badister bullatus* (Schrank) were found that is known to feed on snails. This beetle looks as though its blunt asymmetrical mandibles might be strong enough to break open a shell. It is, therefore, a possible candidate for the type 1 predator. Other candidates are *Cychrus caraboides*, *Carabus coriaceus* and possibly *C. violaceus* and *C. auratus*, all of which are likely to occur at the study site. Further research is required to determine which one or more species of beetle produce this characteristic damage and when they are most active.

The shells of eight *D. rotundatus* showed signs of repair following a type 1 attack (Figure 2). In all cases, the repair material is white and uneven, bulging outwards. The repair does not appear to have any trace of the outer organic periostracum layer or any trace of colour. It is less than a quarter of the thickness of normal *D. rotundatus* shell and is aligned with the inner surface of the shell resulting in an abrupt step down from the undamaged shell. Growth lines on this repair shell suggest incremental repair commencing from the innermost point of damage around the whorl towards the aperture. Repair is more or less parallel to the normal incremental growth, but the repair in contact with the broken edges is in advance of the centre of the damage. As soon as the repair was made up to the original aperture line, the normal shell texture, colour and periostracum layer continued indistinguishable from the normal shell. In winter many snails are less active in laying down shell; species such as *Cepaea* sp. and *Helix aspersa* (Müller) hibernate and an obvious winter rib (varex) is produced. This can also occur if summer aestivation takes place. Some shells seem to sustain a small amount of apertural damage at this time and a slight scar is left when shell growth recommences in the spring. Apertural repair, which is made with normal shell, was most obvious in *D. rotundatus*, *A. nitidula* and *Oxychilus* sp. More than one growth arrest was apparent on many shells. This apertural repair bore no resemblance to the type 1 damage or repaired type 1.

Andrews (1935) noticed a similar phenomenon on marine and freshwater *Neritina virginea* (Linnaeus), when experimentally damaged. Repair near the lip he describes as 'typical' and repair remote from the lip as 'atypical'. Andrews attributes this to the repair being carried out by different parts of the mantle. It is clear that on the *D. rotundatus* which had repaired type 1 damage extending up to half a whorl, the 'atypical' repair shell is not due to mantle edge damage as the shell continues as normal once the original aperture is reached. Carter (1990) describes damage similar to type 1 on *D. rotundatus* from beech woods in the South Downs. Gittenberger (1996) illustrates similar damage, including repaired specimens of *Orculella bulgarica* (Steenberg), which has radially thickened ribs which may have acted as protection against further attack by a predator.

A similar method of predation causing type 1 damage is well known from marine environments where a variety of marine gastropods are attacked by crabs, especially



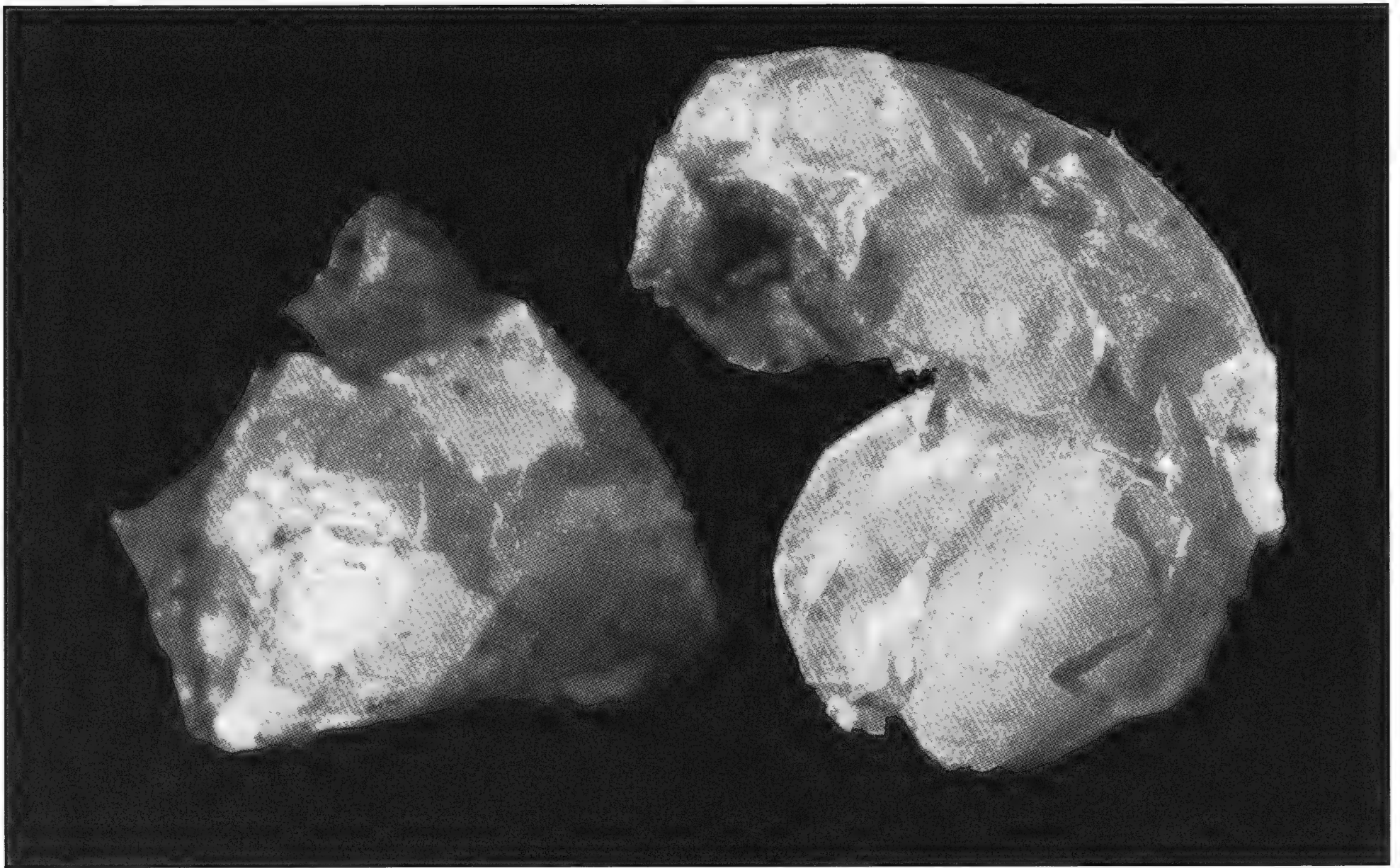
TABLE 4  
Adult and juvenile damaged shells in relation to compartment age.

Compartment	101	122	121	120	112	103	104	116	102	113	111	109	124	123	Total
Age	1	2	3	4	5	6	7	8	9	10	11	12	40	40	
Type 1 - Adult	10		17	12	17	8	10	3	31	2	3	2	3	3	121
Type 1 - Juv	6	12	46	79	119	58	81	13	43	10	23	14	10	24	538
Type 2 - Adult	26	18	57	58	6	78	87	16	143	4	16	42	11	12	574
Type 2 - Juv	8	9	17	29	11	52	43	15	58	22	28	26	6	10	334
Type 3 - Adult	2	2	18	10	5	5	8	3	7	3	4	5	2	6	80
Type 3 - Juv	14	7	44	36	21	22	27	1	20	2	4	2	9	13	222
Type 4 - Adult	2	4	6	3	3	10	10	2	24	2	2	2		2	72
Type 4 - Juv	7	2	7	16	9	31	34	13	37	9	14	8	3	6	196
Type 5 - Adult				2	0			1			1			2	6
Type 5 - Juv		2	3		3	3	1	5	1	5	2		2	2	29
Type 6 - Adult			1			1		1	5						8
Type 6 - Juv		1		1		2	2		2		1				9
Total	75	57	216	246	194	270	303	73	371	59	98	101	46	80	2189
% of total dead	48	53	25	38	35	47	51	61	33	63	62	54	16	64	39

of the genus *Calappa* (Vermeij, 1987, 1993; West, Cohen & Baron, 1991; Quensen & Woodruff, 1997; Rochette & Dill, 2000). There is evidence that defensive ribs, sculpture and thickening may have evolved in response to this predation. Vermeij (1987, pg 228) points out that ‘resistance against shell-breaking predators cannot evolve unless individuals in the population survive shell-breaking attacks’. In this study the means of avoiding predation would appear to be mainly behavioural, cryptic colouration, unpalatability (e.g. *Oxychilus alliarius* (Miller)) or defensive sculpture. Although many of the more common species attacked by the predator(s) causing type 1 damage have thin smooth shells (*C. lubrica*, *Aegopinella* sp, *Oxychilus* sp.), the most commonly attacked is *D. rotundatus* which has a relatively robust shell, with pronounced ribbing. This is the only species on which were found signs of survival from an attack, repair and subsequent growth.

The eight *D. rotundatus* which showed signs of survival and repair (3.5% of living, or 3.7% of T1 damaged) indicate a high casualty rate, and corresponding low potential for selection of resistant traits (Vermeij, 1987). Quensen and Woodruff (1997) found that between 0% and 44% (mean 8%), of snail populations showed signs of survival from crab attack. West *et al*, (1991) found a similar range of survival in freshwater gastropods. It is possible that this sort of predation on *D. rotundatus* and *O. bulgarica* (Gittenberger, 1996) has a role in the evolution of ribs in these species, although Welter-Schultes (2000) found no evidence that shell shape or rib density was a direct response to shell-damaging predators in land snails from Greece.

Type 2. A number of different organisms could have produced the holes associated with type 2 damage, most of which were considered to have occurred on empty shells. Invertebrates are the most likely organisms; the damage was too small and not consistent with small vertebrate damage. Some of the holes observed on the snails from this study were small relative to the shell and are unlikely to have been fatal had the snail been



**Figure 7** Photograph of type 5 damage on two shells of *Vitrina pellucida* showing crumpled periostracum with traces of shell left on the inside. Largest shell approximately 3mm across.

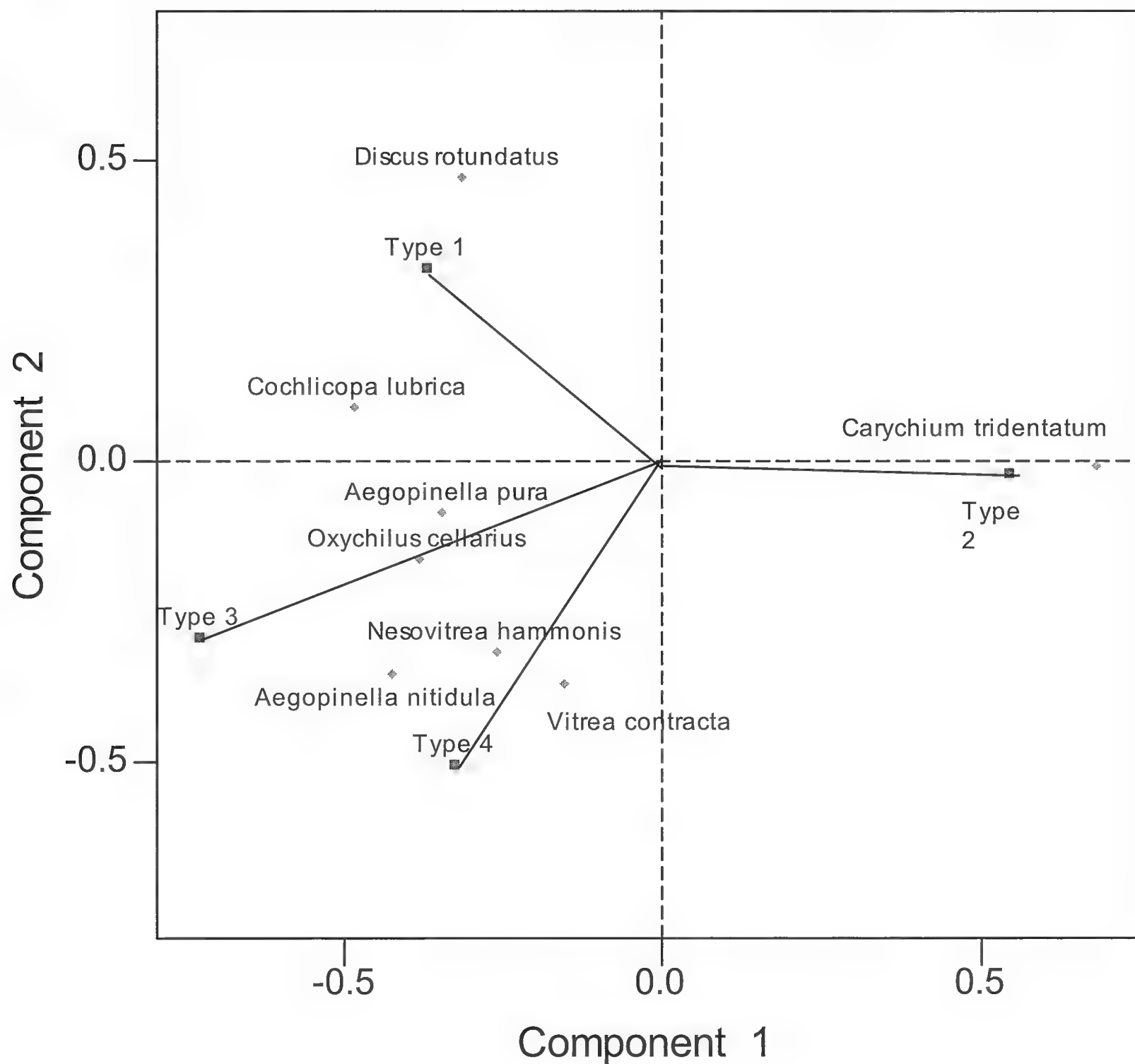
alive, but no sign of repair was found in these samples. It seems probable that snails or other invertebrates grazed the empty shells for the calcium.

Several authors have observed holes in snail shells. Orstan (1999) and Schilthuizen *et al* (1994) found uniform oval or circular holes in Clausiliidae from Turkey and Greek islands, which had either straight or bevelled edges, some of which were probably caused by drilid beetle larvae. None of the type 2 holes matched the description of these holes. The single species of drilid (*Drilus flavescens*, Rossi) in Britain gains entrance via the aperture leaving an unmarked shell (Crawshay, 1903; author personal observation (AM)). Meijer (1985) noted traces of predation of unknown origin on Pleistocene land snails similar to the type 2 damage observed in the present study. Preece (1998) illustrated two predation marks from Quaternary fossil shells but neither bore any resemblance to damage found in this study.

Type 3. Small mammals eating live snails probably caused some of the type 3 damage on larger shells. Other possible causes could include predation by small birds or random physical damage. It is not thought that this damage was caused by thrushes, which tend to prefer the large species such as *Cepaea* sp, and *Helix aspersa* and leave a characteristic pile of broken shells around an 'anvil'. Rats, wood mice and voles eat snails, usually by removing the apex whorls of the shell (Figure 4) (Lamotte, 1950; Illustration of Rat damage: Bang & Dahlstrom, 1974, pg 162; Vole: Lawrence & Brown, 1974, pg 190) or sometimes by breaking the shell from the aperture (Norway rat: Yusa, Sugiura & Ichinose, 2000). Small piles of shells with the apex removed, were found at the study site, especially along the edge of the bridle path, but rarely from the quadrats, mainly being larger species such as *H. aspersa*, *Cepaea* sp and *M. cantiana*.

Type 4. Certain snails such as many *Oxychilus* sp., *N. hammonis*, *V. pellucida* and *A. nitidula*, have been reported to feed on snails and their eggs (Boycott, 1934; Heller,





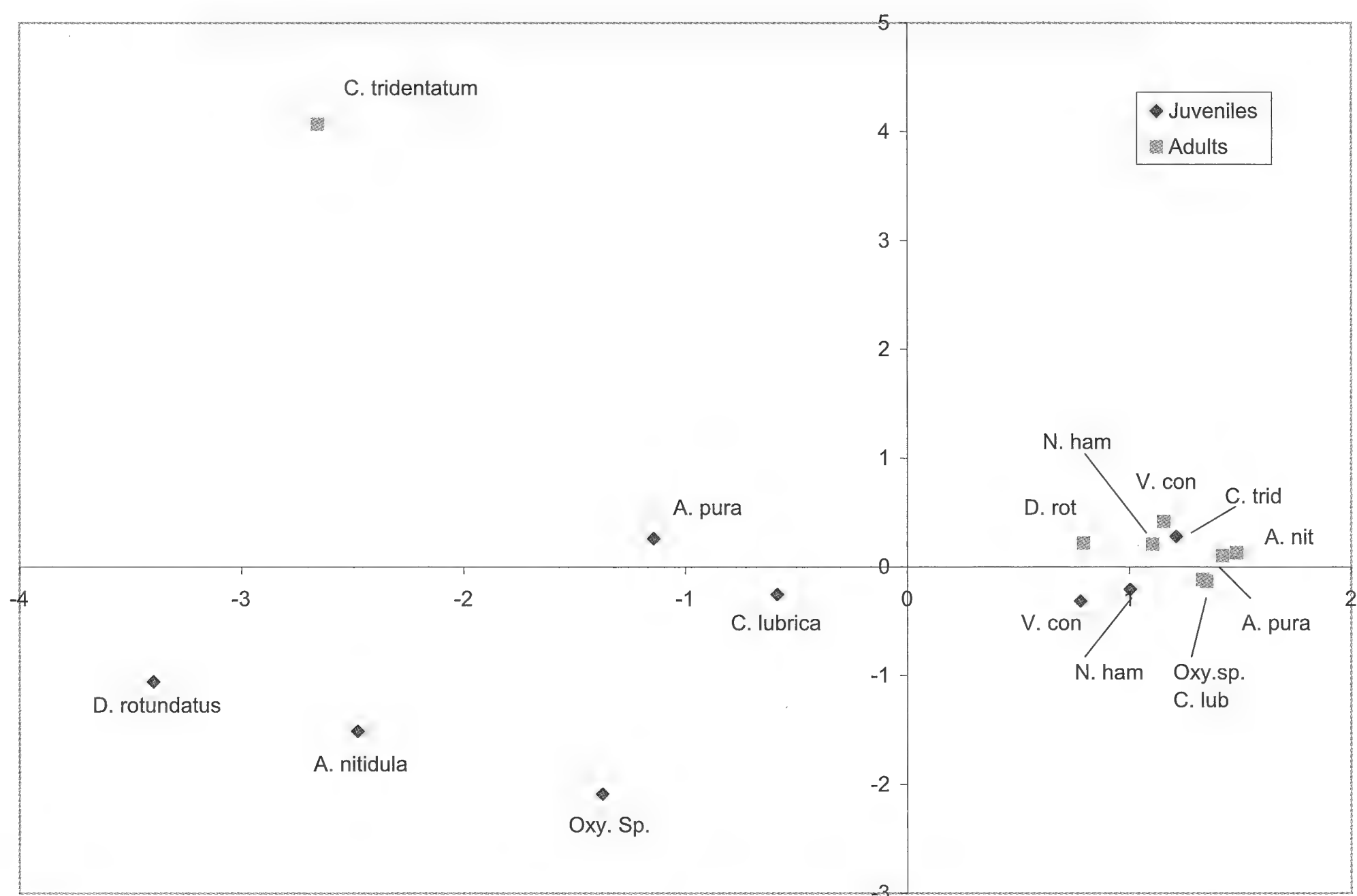
**Figure 8** Simple correspondence analysis joint co-ordinate ordination of damage types and species.

2001), although no shell damage has been reported except for *A. nitidula* predation which causes damage identical to type 4 (Mordan, 1977). Mordan (1977) observed this damage being made only by the predatory snail *A. nitidula* and no other Zonitids he was working on. No signs of repair from this damage were found, suggesting that an attack generally proves fatal when the shell has been completely penetrated. However, a few shells of *A. pura*, *A. nitidula* and *O. cellarius* were found with signs of attempted attacks. The shells of these individuals had not been completely penetrated; the surface layers only had been removed in one small area, in the same location as the type 4 holes were found and bore radulation marks (Figure 6). Mordan (1977) describes finding similar patterns of damage, which he ascribed to failed *A. nitidula* attacks.

Mordan (1977) found that *N. hammonis* were selected in preference to *A. nitidula*, *A. pura* or *Vitrea crystallina*. Table 3 presents data on the abundance of *A. nitidula* to *N. hammonis* at three woodland sites in the UK. The potential prey species *N. hammonis* is relatively more abundant at West Dean, and yet the results suggest that at this site *A. nitidula* preferentially eats members of its own species.

There is a wide disparity of size between the seven snail species most frequently attacked showing type 4 damage; *P. pygmaeum* being the smallest with a diameter of 1.5mm or less, and *P. elegans* which when fully grown may be 11mm x 16mm high. Mordan (1977) found that only animals with shell width between 3.5mm and 4.5mm were eaten in this way. This study found damage on a wider range of sizes. The extent of type 4 damage to *P. elegans* is a little surprising. This thick-shelled species is the only





**Figure 9** Ordination of species based on their patterns of shell damage.

(V. con= *Vitrea contracta*, N. ham = *Nesovitrea hammonis*, Oxy. Sp = *Oxychilus* spp., A.nit = *Aegopinella nitidula*, C. trid = *Carychium tridentatum*, D. rot = *Discus rotundatus*)

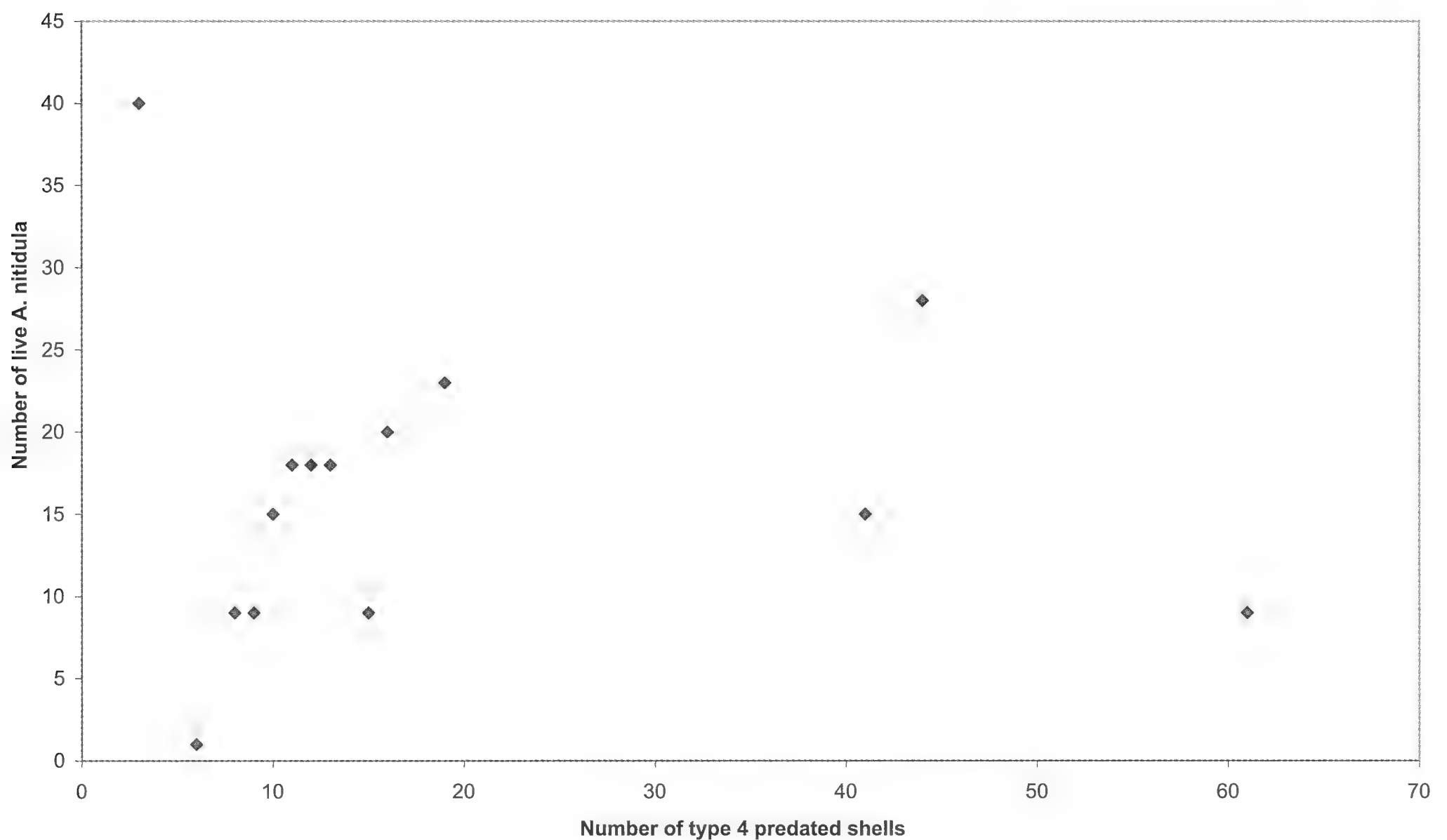
one found on this site with an operculum which ought to provide some protection from this form of predation (Berg, 1964; Vermeij, 1993; Gittenberger, 1996), which starts at the opening and when the foot is eaten, a hole is then made in the side of the shell and the body extracted (Mordan, 1977).

Type 5. It is not known what causes the damage type 5, which may be chemical or biological, however, Kasigwa *et al* (1983) noted similar damage left after predation by the snail *Edentulina obesa* in Tanzania.

#### PATTERNS OF MORTALITY AND POTENTIAL EFFECTS ON POPULATION

The causes of mollusc death are rarely clear from an undamaged empty shell. Glow-worm, fireflies), *Tetanocera* spp., Sciomyzidae fly and certain beetles parasitize snails as larvae leaving the shell undamaged (Crawshay, 1903; Askew, 1971; Greene, 1975; Barraclough, 1983). Fly pupal cases and drilid beetle *Drilus flavescens* larval skins may be found in the shell (Millar personal observation from study site) indicating this cause of death. Food quality (Chatfield, 1976; Speiser, 2001) and desiccation (Heller, 2001) are possible causes of death, as is disease although there is little information on this and they appear to have a detoxification mechanism and hence tolerance for potentially damaging trace metals (Dallinger, Berger, Triebkorn-Kohler & Kohler, 2001),

Where distinctive patterns of shell damage do remain after death, as with certain types of predation, it is possible to ascribe mortality to particular causes. For the snail species present at this site, it would appear that a minimum of 17% (Types 1 and 4) and potentially over 22% (types 1, 3 and 4) of snail mortality was due to predation which left some mark on the shell. Between 42% and 56% of the damage left on the shells is



**Figure 10** The relationship between numbers of shells predated by *Aegopinella nitidula* and the number of live *A. nitidula* in the coppice compartments (mean of four quadrats).

likely to have been caused by predation. It should be noted that beetles will feed on already dead prey. However, no evidence was found to suggest any of the snails were already dead when attacked by the beetles and evidence has been discussed regarding this predation (type 1) being on live snails (e.g. repair of shell).

The impact of this level of predation on populations will differ between species and whether predated snails are pre-reproductive juveniles or adults. The apparent rates of predation did not reflect species abundance. Of the five species incurring the highest proportion of shell damage (*C. tridentatum*, *D. rotundatus*, *A. nitidula*, *N. hammonis* and *Oxychilus* sp.) only the first three were among the most abundant snails available (Millar & Waite, 1999). Most of the species found in this woodland are hermaphrodites and lay clutches of between 20 and 100 eggs. While many small species are semelparous (reproduce in one season and die) and short lived (e.g. *V. pellucida*), larger ones may survive to breed again the following year (Heller, 2001). For species with high fecundity and relatively short lifespans the loss of reproductive adults might be expected to suppress population size (Roff, 1992). Of shells with type 1 and type 4 damage, 82% and 73% respectively were classed as non-breeding juveniles. Despite the high level of type 1 and type 4 predation, which accounted for 31% of *D. rotundatus* mortality, this species remained among the most abundant at the study site. Evans (1972) and Boycott (1934) have noted high juvenile snail mortality, although there is little information on the causes and frequency of this mortality (Heller, 2001), or whether predation is a major determinate of population density.

Boycott (1934) considered that neither predators nor parasites were effective in localising the distribution of a particular snail species, however, long lived, slow breeding snail species of the Negev desert observed by Shachak *et al* (1981) suffered greatly from thrush predation which was estimated to account for 10-70% mortality and severely affected the population. Welter-Schultes (2000) found successful drilid (beetle) attack accounted for over 50% of Mediterranean *Albinaria* snail mortality, Schilthuizen

*et al.* (1994) found between 7% and 51% of dead *Albinaria* had been attacked by drilid larvae, but an unspecified number of live snails had survived an attack. Orstan (1999) found predators leaving drill hole evidence, accounting for between 20% and 88% of *Albinaria* mortality. Kasigwa *et al.* (1983) found between 12% and 68% mortality caused by predators, mainly by the snail *Edentulina obesa*. Vermeij (1987) cites a range of mortality rates due to predation involving drilling and breakage of marine shells. The severe effects of predation on the snail population reported by Yom Tov (1970) and Shachak (1981) resulted from a sudden increase in predator abundance and the lack of alternative prey species. In the present study, the range of damage types and their occurrences among the shells of different species, suggest that while the predators may have preferences, they commonly attack more than one species. This will reduce the likelihood that a particular predator will cause a drastic reduction in the population of a single species.

Of the snails recovered in the study 62.6% were dead. This value is similar to that reported by Ward Booth, Dussart & Paglia (1996) who found that among samples from farmland near Saffron Walden, Essex, UK, 68% were dead. While the live assemblage in this study closely resembled the recent death assemblage (Millar & Waite, 1999) other studies have found that death assemblages (recent, long-dead and fossil) can become skewed for a variety of reasons (Carter, 1990; Rundell & Cowie, 2003) and understanding the causes of death and condition of shell when it joins the death assemblage can contribute to the interpretation of palaeoenvironmental data.

## SUMMARY

There are many types of shell damage affecting woodland snails, two examined in this study are believed to be as a result of predation by a snail and a beetle. The impact of these two predators (17% of total mortality) was large but spread over predominantly the juveniles of a number of species. The presumed snail predator also eats its own species preferentially.

While there is no evidence from this study to indicate that predation is adversely affecting the population in this woodland, there is data from elsewhere to demonstrate that predators can have an effect on some snail populations (Yom-Tov, 1970; Shackak *et al.*, 1981). The only species to show signs of survival and repair was also the only species to possess pronounced ribs, which may be of survival benefit. In spite of this species (*D. rotundatus*) suffering the highest predation rate it remains a very common snail.

Approximately one third of the shells showed signs of damage, the majority of which was on juvenile snails. The proportions and frequency of damage varied during coppice succession. Types of damage as a result of predation and after-death shell damage show some of the ways in which shells can be rapidly broken down and recycled. Although in this woodland the assemblage of empty shells closely matched the live assemblage, with other environmental conditions, the death assemblage may become skewed. Understanding the predation marks and death assemblage on useful indicators such as snails may assist the interpretation of archaeological and palaeoenvironmental evidence, and shed light on the evolution of shell sculpture.

## ACKNOWLEDGEMENTS

We would like to thank Peter Hodges for the identification of the insects in samples, Gerald Legg of the Booth Museum of Natural History, Brighton, for assistance with



beetle and harvestman predators, B Verdcourt and P Mordan for helpful advice, Stuart Hine, Natural History Museum, London, for identifying the *Drilus flavescens* larva. We are also grateful to the Conchological Society of Great Britain and Ireland and to English Nature for grants enabling A.J.M. to carry out the initial fieldwork. We should also like to thank the Sussex Wildlife Trust and The Trustees of the Edward James Foundation for permission to work on the reserve.

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# THE DISTRIBUTION AND ECOLOGY OF *GYRAULUS ACRONICUS* (FÉRUSSAC, 1807) (GASTROPODA: PLANORBIDAE) IN ENGLAND

IAN J. KILLEEN<sup>1</sup> & BEN MCFARLAND<sup>2</sup>

*Abstract* Populations of the planorbid *Gyraulus acronicus* have been surveyed in four rivers in the upper catchment of the River Thames, England. The species appears to be restricted to short sections of each river near their confluences with the Thames. The habitats are characterized by clean, slow-flowing calcareous water and densely vegetated margins. Recent evidence suggests that the species is very restricted in its distribution in England and therefore conservation of *G. acronicus* should have a high priority in the management programmes for the rivers that support the species.

*Key words* *Gyraulus acronicus*, distribution, UK Biodiversity Action Plan

## INTRODUCTION

*Gyraulus acronicus*, known (in Britain) as the Thames ram's-horn, has a very restricted geographical distribution in Britain and is rarely recorded living (Kerney 1999). The British Red Data Book (Bratton 1991) categorises the species as Vulnerable (RDB 2): Taxa believed likely to move to the Endangered (RDB 1) category in the near future. The category includes taxa whose populations are decreasing because of excessive habitat destruction or other environmental disturbance; taxa with seriously depleted populations and whose ultimate security is not yet assured; and taxa with populations that still may be abundant but are under threat from serious adverse factors throughout their range. *G. acronicus* is also listed as a Species of Conservation Concern (SoCC) under the UK Biodiversity Action Plan (BAP) (formerly the 'long-list' in HMSO 1996). Willing (2003) notes that species on the SoCC list have received much less attention than the BAP Priority species, although in some instances, they may be more deserving of conservation. *G. acronicus* is the only Species of Conservation Concern dealt with by the UK BAP freshwater mollusc Steering Group.

Kerney (1999) shows records from 23 ten kilometre squares: 10 post-1965, 4 pre-1965, and a further 9 with Holocene fossil records only. All of the modern records are from the upper part of the River Thames catchment: in the main Thames from Lechlade through to Wraysbury, the R. Cherwell between Kidlington and Oxford, and single records from the R. Evenlode south of Long Hanborough, the R. Kennet at Reading and the R. Loddon at Stratfield Saye. Most of the Holocene records are from the lower part of the R. Thames and from the R. Lea, showing that the species was formerly more widespread. Many of the records from the early part of the 20<sup>th</sup> century refer to living animals (Winckworth 1923; Cooper 1924a, b; Ellis 1926, 1927). However, a significant portion of the records made since the 1920s are based upon dead shells collected from flood debris.

*G. acronicus* is also known from earlier fossils e.g. in the Thames deposits of Middle Pleistocene age at Sugworth (Preece 1989), Thames deposits of Hoxnian age at Swanscombe, Kent (Kerney 1971), and from outside the Thames catchment in Middle Pleistocene deposits near Peterborough (Preece pers. comm.)

*Gyraulus acronicus* is a central and northern European species occurring from England to the Baltic States, and from the Alps to northern Scandinavia (Falkner *et al.* 2001, Glöer 2002). The species is unknown in France and Belgium and occurs in the Netherlands only as Holocene fossils, thus the British population is relatively isolated.

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In 2000 and 2001 living populations of *Gyraulus acronicus* were found in the rivers Windrush and Evenlode in Oxfordshire, and the River Pang in Berkshire (Killeen pers. obs.). The species had also been found living in Back Water (an old leat of the R. Thames) near Abingdon during an earlier survey (Killeen 1998).

Following on from these discoveries a study was initiated and funded by the Environment Agency (Thames Region, Wallingford, Oxfordshire) to determine the status of *Gyraulus acronicus* in these four Thames catchment rivers. This paper presents the results of the study, which includes details of the species' habitat, distribution and abundance together with comments on life-history, taxonomy and conservation.

## METHODS

Previous sampling of the rivers of the Thames catchment (Figure 1) had given a broad indication of the sections of each river inhabited by *Gyraulus acronicus*. Therefore the present study focused on a more detailed sampling of these identified sections. The R. Evenlode (Oxfordshire) was sampled over an approximately 7km long section from Long Hanborough (National Grid Reference SP438137) to the confluence with the River Thames downstream of Cassington (NGR SP454097). The R. Windrush was sampled over 7km between Hardwick (NGR SP382067) and Newbridge near the confluence with the R. Thames (NGR SP401017), the R. Pang over 2km between Tidmarsh and Pangbourne (NGR SU635743 to 632761), and a 1km section of Back Water south of Abingdon (NGR SU507964 to 501958). The main R. Evenlode and the Back Water surveys were carried out in July 2001, the R. Windrush in November 2002, and the R. Pang in July 2001 and April 2003. Repeat sampling at selected sites on the R. Evenlode and R. Windrush was carried out in 2002 and 2003.

Sampling was carried out from the banks using an extendable, robust, aluminium-framed pond net (handle and frame 2.4m in length, equipped with a 0.5mm nylon mesh bag). Snails were collected by vigorously agitating aquatic plants and the surface of the sediment for approximately 30 seconds. The bag and contents was then drawn through the river to sieve out fine sediment. The resultant sample was then tipped into a large white plastic tray, agitated in water to release snails from the weed, allowed to settle, and then snail-free vegetation and organic detritus was removed. The mollusc-rich residue was then examined in the tray and all specimens (live animals and dead shells) of *G. acronicus* were counted. Generally, three to six samples were taken at each location. Samples of *G. acronicus* from selected sites were collected and measured, and in most cases, returned to the rivers the following day.

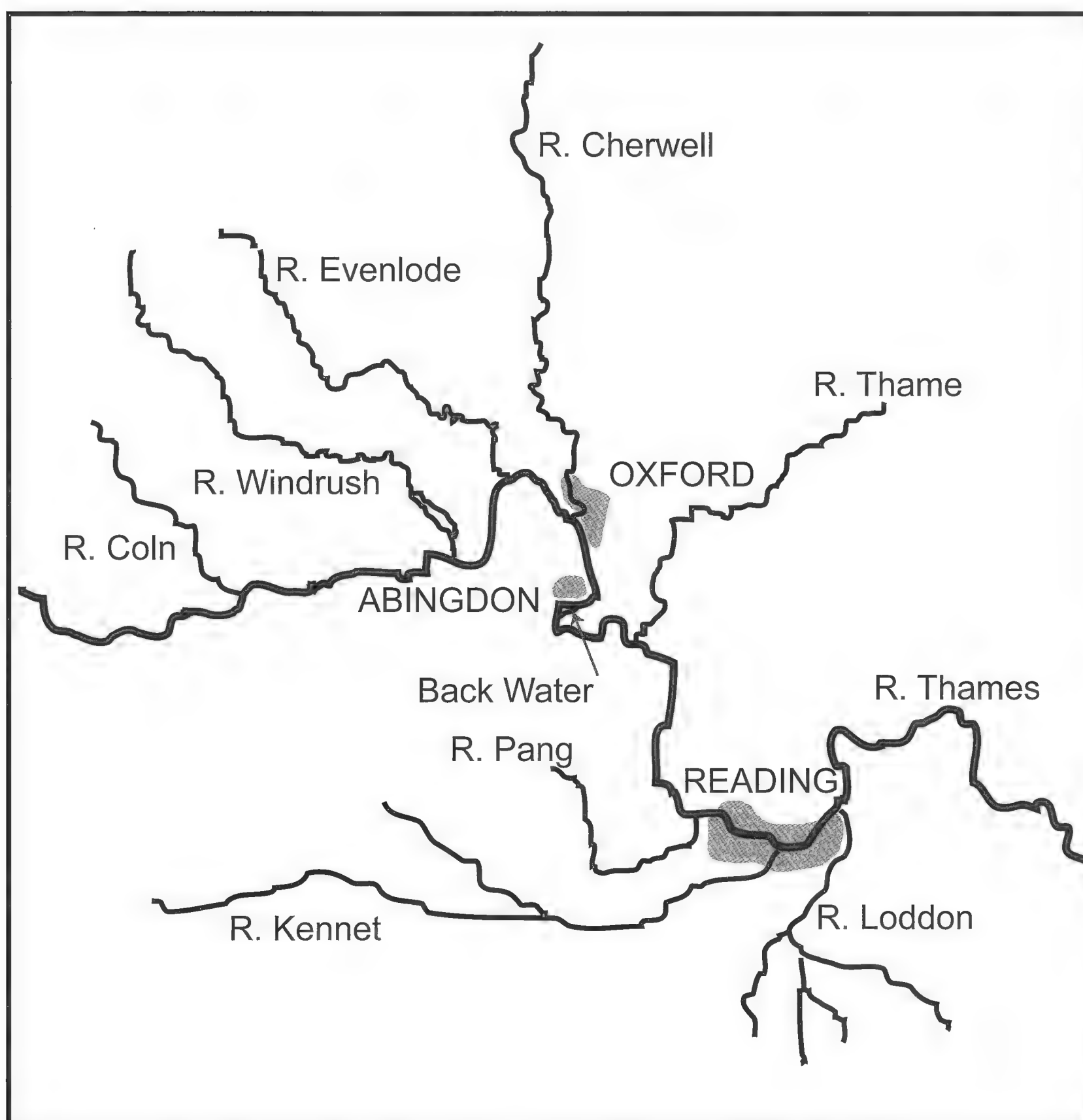
At each site, the habitat and aquatic mollusc species were recorded. Environment Agency data on water quality was obtained for sample stations within the survey sections.

## RESULTS

A brief description of the habitat with the section of each river surveyed is given in Table 1.

Tables 2-5 give the details of the locations of the sample sites (in downstream order) along with the number of samples and numbers of living and dead *G. acronicus* recorded.

The gross distribution of *G. acronicus* in the study rivers was broadly determined prior to the present survey. In the R. Evenlode *G. acronicus* was recorded (July 2001) in 21 of



**Figure 1** The catchment of the upper Thames

the 29 sample sites and was absent principally from the upstream and downstream ends of the section sampled (Table 2). In the R. Windrush dead shells were found (November 2002) at all 8 sample sites but living individuals were collected only at site 3 and in the three close-together sites (2-4) upstream of Beard Mill (Table 3). Living *G. acronicus* were found (April 2003) in 8 of the 12 sites sampled on the R. Pang although the distribution was patchy (Table 4). In Back Water *G. acronicus* was found only at site 3 (Table 5).

In the R. Evenlode 287 living *G. acronicus* were obtained (July 2001) from 29 sites (mean 9.9 individuals/site) and 119 separate samples (mean 2.41/sample). There was considerable variation between sites with the number of individuals/sample ranging from 0-14.5. Sites 16 and 17 supported the highest abundances by far with 13.7 and 14.5 individuals/sample respectively, whereas the site with the next highest abundance (site 18) only had 5.7 individuals/sample. Much lower abundances were recorded at site 17 in November 2002 and April 2003. In the R. Windrush 27 living *G. acronicus* were obtained (November 2002) from 8 sites (mean 3.4 individuals/site) and 51 separate samples (mean 0.53/sample). At site 4 where *G. acronicus* was most abundant, the mean numbers of individuals/sample were higher in April 2003 (5.6) than in November 2002 (2.2). The species was much less abundant in the R. Pang with 1.44 individuals/sample recorded in July 2001 and 0.54 recorded in April 2003. In Back Water only a single live individual was found (at site 3).

Tables 2-5 also show the measurements of the shells of *G. acronicus*, also presented

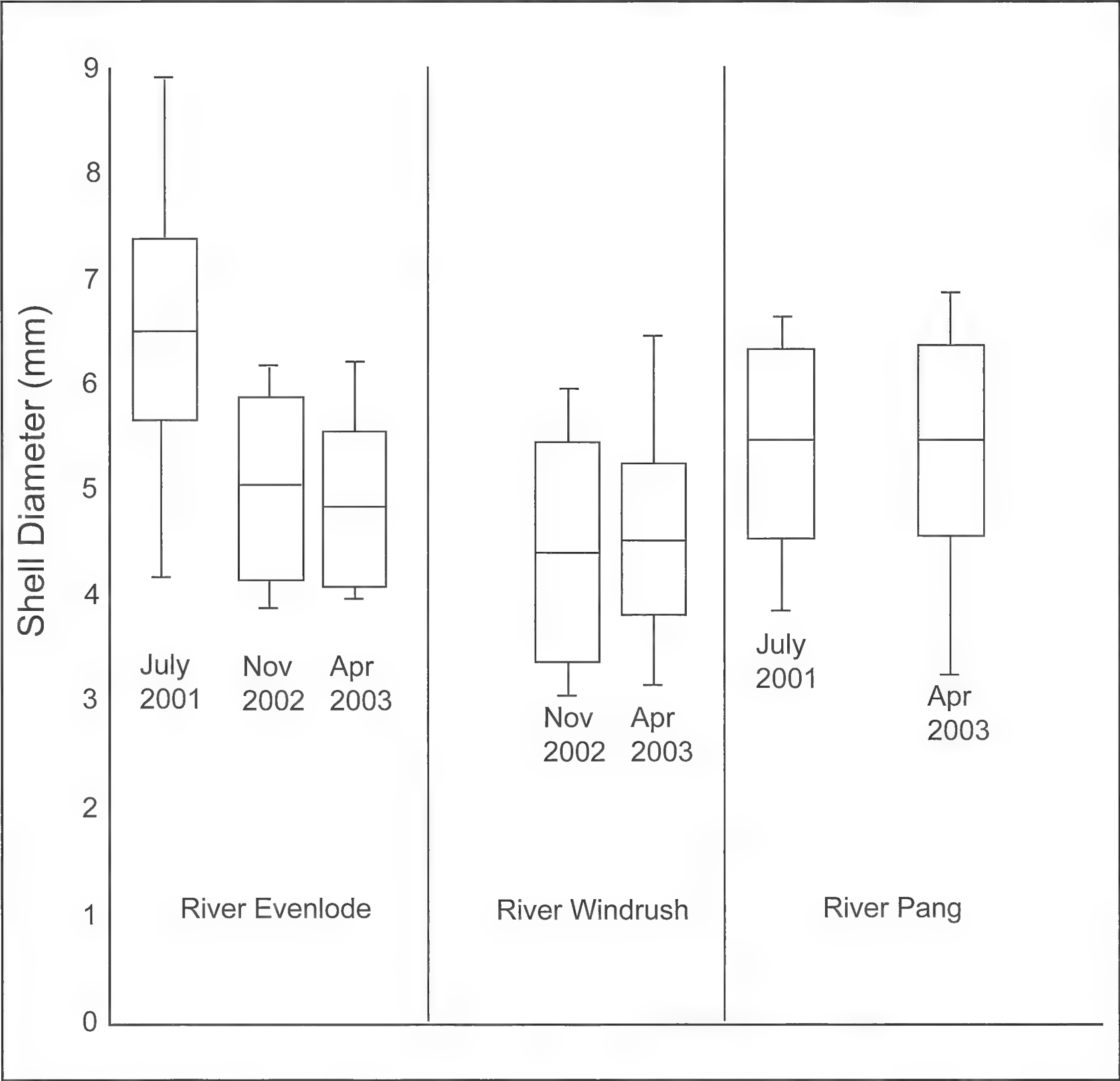


Figure 2 Measurements of shell diameter, showing size range, mean and standard deviation (boxed)

graphically in Figure 2. In the R. Evenlode in July 2001 the population was dominated by adult individuals (mean shell diameter 6.52mm) but comprised a wide size range (4.2-8.9mm). In November 2002 and April 2003 the mean shell size was similar (5.05 and 4.85 mm respectively) falling in the range 3.9-6.2mm showing that there had been virtually no growth over the winter. A similar result was obtained for the R. Windrush between November 2002 and April 2003, although the mean shell sizes (4.42 and 4.57mm) are smaller than those from the R. Evenlode. No specimens were collected from the R. Pang in November 2002. However, the mean shell diameters are the same (5.5mm) in both July 2001 and April 2003, although there is a wider range in the latter. The results also indicate that the shells of the *G. acronicus* population in the R. Evenlode grow to a larger size (8.9mm maximum diameter) than those in the R. Windrush (6.5mm max) and R. Pang (6.9mm max).

Table 6 shows the aquatic mollusc species recorded in the surveyed sections of each of the 4 rivers. A total of 34 species (21 gastropods, 13 bivalves) were found with the fauna of the individual rivers ranging from 23 species in the R. Pang to 28 species in the R. Evenlode.

Environment Agency water quality data derived from monthly sampling between 1990 and 2002 at locations nearest to those sampled in the present study, are summarised in Table 7.



## DISCUSSION

Opinions have been expressed over the taxonomic status of British *Gyraulus acronicus*. Kerney (1999) notes "The taxonomy of the genus *Gyraulus* is complex and the identity of this particular British form with the species known under the same name in mountain lakes in Scandinavia and the Alps is not firmly established". Confusion arises from the similarity in shell morphology of *G. acronicus* to *G. albus* (Müller, 1774) and there is therefore the suggestion that the taxon referred to as *G. acronicus* in Britain may be no more than a peculiar ecophenotype of *G. albus*. Furthermore there is dissimilarity in the ecology of *G. acronicus* between Britain and some other parts of its range.

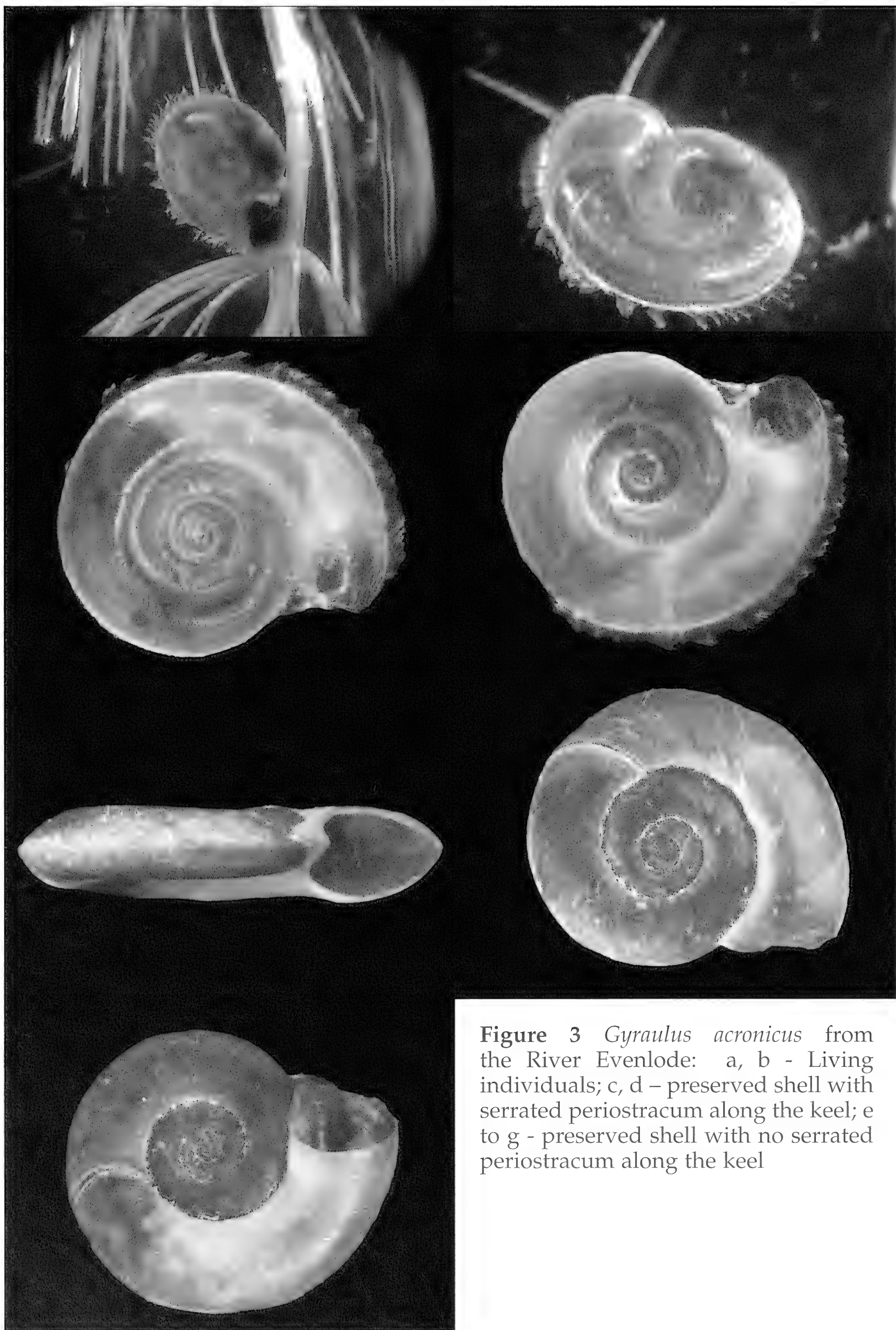
The shells of the specimens of *G. acronicus* from the rivers in this study compare well with those described and illustrated by Økland (1990) and Glöer (2002). Based upon specimens collected in July 2001, adults have a shell with 4-5 whorls, and a diameter between 5.5 and 6.5mm, with a maximum of 8.9mm. The shell is flattened with a conspicuous peripheral keel and a sculpture comprising transverse striae, with occasional faint spiral striae (Figure 3, e-g). The periostracum in many specimens extends beyond the periphery either as a smooth or serrated seam (Figure 3, a-d). Anatomically, the prostate gland has over 20 diverticulae and compares well with the illustrations in Glöer (2002). *Gyraulus albus* is smaller, with a shell diameter of 4 to 6mm, reaching 7mm maximum. The whorls are rounded or with a slight peripheral keel and a sculpture of conspicuous spiral striae and fainter spiral striae. The periostracum is bristly and is often conspicuous when raised up on the spiral striae. The prostate gland usually has less than 20 diverticulae.

Many of the studies on *G. acronicus* are from Scandinavia and in particular Økland's (1990) work on Norwegian lakes where the species is common. Økland describes the species as occurring in a wide range of habitats, preferring lakes and slow-flowing rivers. It occurred most frequently in richly-vegetated habitats and water with a pH >6.8. Glöer (2002) states that *G. acronicus* lives mostly in lakes in areas with gravelly bottom substrate but can also be found in slowly-flowing waters and smaller lakes. In Britain the species occurs in richly-vegetated, slow-flowing rivers.

The photographs of the British *G. acronicus* used in this paper have been sent to Peter Glöer who concludes that they are the same as those referred to by the same name elsewhere in Europe. Until molecular or other studies further elucidate the taxonomy of the genus *Gyraulus*, we conclude that British and European *G. acronicus* are conspecific.

The results of this study have demonstrated that populations of *G. acronicus* survive in the River Thames catchment. In the R. Evenlode it occurs almost continuously over a 5km long section from south of Long Hanborough to Cassington. At some locations it was common. The populations in the R. Windrush and Pang are much more restricted in their distribution, sections of c. 2km in both, although in the R. Windrush *G. acronicus* was locally frequent. The species was very rare in Back Water, only a single living individual was recorded, at the same location where it was found in 1998 (Killeen 1998). In 2001, single dead shells of *G. acronicus* were also found in the River Thame at Lower Grange and in the R. Cherwell at Shipton-on-Cherwell and Hampton Poyle (Killeen pers. obs.). Given that some of the shells were translucent, it is possible that living populations [of the species] survive in these rivers, although they may be very localised.

In all the rivers studied the populations of *G. acronicus* were living in sections close to their confluences with the main River Thames. However, there are no clear reasons for these apparently restricted distributions. Whilst the populated sites in the R. Evenlode, R. Windrush and Back Water are all characterised by slow-flowing water with their margins densely vegetated by tall plants such as *Schoenoplectus tabernamontanae* (Figures 5&6), the R. Pang is swift-flowing with sparse marginal vegetation (Figures



**Figure 3** *Gyraulus acronicus* from the River Evenlode: a, b - Living individuals; c, d - preserved shell with serrated periostracum along the keel; e to g - preserved shell with no serrated periostracum along the keel



7). In the R. Evenlode similar habitat to that in the populated section is present for at least another 10km upstream but *G. acronicus* is absent. Within the section of the R. Evenlode sampled during this study, *G. acronicus* was absent only in places where the river was swift-flowing, poorly vegetated or canalised. The R. Windrush is generally a swift-flowing river and with the exception of the Beard Mill site, the river has very few slow-flowing, densely vegetated sections. Differences in water quality do not account for the differences in *G. acronicus* distribution. The R. Windrush and R. Pang are clean, calcareous rivers with similar levels of nitrate, orthophosphate and BOD (Table 7). The R. Evenlode has a much higher level of orthophosphate yet it supports the greatest *G. acronicus* population in terms of distribution and abundance. River management may also be factor, although a section of the R. Evenlode at Cassington is regularly dredged and the lower R. Pang was dredged between July 2001 and April 2002, but *G. acronicus* has survived in both.

To gather information on the life-history of *G. acronicus* would have required monthly sampling over at least one year, and which was beyond the scope of this study. However, based upon the limited amount of biometric data it may be inferred that the species is an annual. Adults dominate in July and half to two-thirds grown individuals are present in November and April. In the R. Evenlode the mean shell diameter was 6.52mm in July 2001, 5.05mm in November 2002 and 4.85mm in April 2003. Individuals under 3.5mm in diameter were rare at any time but given the range of shell sizes in the samples it seems likely that breeding occurs in early summer, the majority of adults die-off in late summer and there is little growth over winter, the snails completing their growth in spring and early summer. A similar life-history was described for another planorbid species (*Anisus vorticulus*) in East Anglia (Killeen 1999).

The aquatic molluscs of the Thames catchment rivers are relatively well-recorded and therefore, it is surprising that the *G. acronicus* populations in the R. Evenlode, R. Windrush and R. Pang have gone undiscovered. It is possible that the species may have been overlooked or mistaken for another species such as *Planorbis carinatus* Müller, 1774. In the field, large, strongly-keeled specimens of *G. acronicus* bear a superficial resemblance to *P. carinatus*, a fact remarked upon by Cooper (1924a). Small, less strongly-keeled specimens may have been mistaken for *Gyraulus albus*.

There are remarkably few accounts of British occurrences of *G. acronicus* in the literature and less than 30 records held by the Conchological Society of Great Britain & Ireland, thus any change in the status of the species is difficult to assess. However, based on these records there is no evidence of *G. acronicus* living in the main River Thames since 1974. A survey of the section between Oxford and Dorchester (c. 22km) yielded only occasional old shells (Killeen 1998). Subsequent fieldwork by one of us (IJK) of the Thames between Cricklade and Reading (c. 120km) again yielded only an occasional dead shell. This strongly indicates that *G. acronicus* is either very restricted or no longer lives in the R. Thames itself, and is now confined to its tributaries. There may be several reasons for the apparent disappearance, but the effects of boat traffic may be a primary cause. The R. Thames supports a major leisure craft industry throughout the navigable section of the river. The presence of moorings, locks and marinas, combined with the effects of dredging the channel, and bow waves from the continuous boat traffic have to a considerable extent, affected the habitat, such that there are now few areas with quiet, stable and well-vegetated margins. None of the three tributaries have any boat traffic. There is insufficient data to determine whether differences in water quality would account for the absence of *G. acronicus* from the R. Thames. Nitrate, nitrite and BOD levels from the R. Thames at Godstow, north of Oxford, are within the range of those from the three tributaries. The level of orthophosphate at Godstow (0.29mg/l) is slightly higher than that from the R. Evenlode at Cassington, but significantly higher than for the R. Windrush and R. Pang.





Figure 4 *Gyraulus acronicus* habitats:  
a, b - River Evenlode site 17; c, d - River Windrush site 6; e, f - River Pang site 4

## CONSERVATION

The R. Evenlode generally has good water quality, although significant lengths of the river have been dredged and deepened in the past. This, coupled with a loss of floodplain features such as backwaters, has resulted in a poor to moderate diversity of channel and riparian habitats. The R. Evenlode flows through the Upper Thames Environmentally Sensitive Area (ESA), and many of the bankside habitats have been restored though the prioritization of conservation within ESAs. The good water quality enables the Evenlode to retain a high invertebrate diversity and a number of rare species have been recorded including the IUCN Endangered riffle beetle, *Normandia nitens*.

The R. Windrush catchment is one of the most notable in the Upper Thames for the ecological value of its river and flood plain habitats. There are twelve sites of Special Scientific Interest (SSSI) in the catchment. The river contains a number of colonies of the rapidly declining water vole (*Arivola terrestris*) and otter (*Lutra lutra*) are now established following the successful reintroduction in the early 1990s.

The R. Pang has no specific conservation designation, but all Chalk rivers are a Priority 1 Biodiversity Action Plan (BAP) habitat. This places responsibility on competent authorities to maintain and, where possible, improve the habitat of all Chalk rivers. The R. Pang is one of the least polluted rivers in the Thames catchment and contains a high diversity of aquatic invertebrates. A number of nationally notable species have been recorded along the river including a breeding population of club-tailed dragonfly, *Gomphus vulgatissimus* at the confluence with the Thames. Back Water also has no conservation designation.

In addition to *Gyraulus acronicus*, the rivers Pang, Evenlode and Windrush all support the fine-lined pea mussel, *Pisidium tenuilineatum* Stelfox, a species listed as a Priority on the UK BAP. In the R. Evenlode and R. Windrush, *P. tenuilineatum* occurs upstream of the sections inhabited by *G. acronicus*, whereas in the R. Pang, the species also occurs within the section with *G. acronicus*.

The results of this survey have indicated that overall *G. acronicus* has a preference for slow-moving water and densely vegetated river margins. The water quality is generally good but there is insufficient data to indicate upper levels for components such as nitrate and phosphate. The population of *G. acronicus* in the R. Evenlode appears to be thriving over a distance of 6km, but in the R. Windrush, R. Pang and Back Water it has a much more restricted distribution, although in places it was frequent. However, it appears likely that these four waterbodies, and perhaps along with the R. Cherwell and R. Thame, support the entire British population of the species. Whilst the R. Evenlode population may be relatively secure, the others are vulnerable. It is hoped that conservation of *G. acronicus* will be considered within the management programmes for these rivers.

## ACKNOWLEDGEMENTS

We are grateful to the Environment Agency (Thames Region) for funding this survey and to the landowners who gave permission for the rivers to be accessed from their land. We also thank James Turner (National Museum of Wales) for the colour images of preserved *G. acronicus*, Richard Preece (University of Cambridge) for useful discussion and comments on the manuscript, and Peter Glöer for giving his opinion on the photographs.

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TABLE 1  
General habitat descriptions for the surveyed sections of each river

River	Description
Evenlode	The River Evenlode rises above Moreton in Marsh from gravel and boulder clays overlying Lower Lias clays. Further downriver, after flowing over extensive areas of clay, the Great Oolite aquifer contributes to the flow. In the surveyed section the river was 6-8m wide and generally >0.7m deep. Water flow varied from slow to negligible, and the substrate was silty. The margins were vegetated by <i>Sparganium erectum</i> and <i>Glyceria maxima</i> , dense in places. Some sections had extensive stands of <i>Schoenoplectus tabernamontanae</i> in the channel and along the margins. Other plants included <i>Nuphar lutea</i> and <i>Cladophora</i> sp. There was little shading by trees.
Windrush	The River Windrush rises in the Cotswolds, approximately 4km north of the village of Temple Guiting, and flows for 73km, joining the Thames at Newbridge. The upper reaches of the Windrush and its main tributary, the River Dikler, are fed with high quality water from Oolitic limestone springs. The surveyed section was a mostly moderate to swift-flowing river, 6-8m wide and 0.6-1.1m deep and a wide range of substrate size. The marginal plants varied considerably in distribution and density. The section upstream of Beard Mill (sites 4-6) was slow-flowing to standing with a silty substrate and densely vegetated margins – similar to that described for the R. Evenlode above. There was little shading by trees.
Pang	The River Pang is a rural Chalk stream, 23km in length, which rises to the north of Hampstead Norreys in Berkshire and joins the Thames at Pangbourne. In the survey section it was a swift-flowing, clear stream, mostly <5m wide and <0.5m deep. The substrate comprised mostly coarse sand and gravel with some areas of marginal mud. The margins were sparsely to moderately vegetated by <i>Carex riparia</i> , <i>Spaganium erectum</i> , <i>Phalaris arundinacea</i> , <i>Myosotis scorpioides</i> and <i>Mentha aquatica</i> . The river had areas of <i>Rorippa nasturtium-aquaticum</i> and <i>Ranunculus aquatilis</i> . The left bank had discontinuous tree cover.
Back Water	This was a slow-flowing channel, c. 5m wide and mostly >1m deep. The banks were densely vegetated by herbs and scrub, and shaded by trees along the northern bank. Some areas supported <i>S. tabernamontanae</i> . Just before the confluence with the R. Thames there was an open, broad sheltered embayment with a muddy substrate and densely vegetated margins, mostly <i>Carex riparia</i> .

TABLE 2  
River Evenlode: sample locations, numbers of *G. acronicus* and shell measurements

Date	Site	Grid	No. of	<i>Gyraulus acronicus</i>		Shell Diameter (mm)			
	No.	Reference	samples	Live	Shells	n	Mean	Range	σn-1
10/11 July 2001	1	SP43761375	5	0	0				
	2	SP43851365	5	0	0				
	3	SP43901361	5	0	0				
	4	SP43931360	5	0	0				
	5	SP44051341	5	7	5				
	6	SP44211324	5	4	0				
	7	SP44221315	6	19	1	16	6.50	5.9 – 7.2	0.50
	8	SP43971263	4	2	0	}			
	9	SP44111289	4	4	0	}			
	10	SP44251295	4	2	3	}			
	11	SP44351293	4	0	0	}			
	12	SP44471290	4	0	0	} 25	6.38	4.2 – 8.9	1.30
	13	SP44481254	4	2	1	}			
	14	SP44171253	4	13	3	}			
	15	SP43891243	5	6	2	}			
	16	SP43801211	4	55	2	} 54	6.71	4.4 – 8.6	0.73
	17	SP43861191	4	58	3	}			
	18	SP43901169	4	23	0				
	19	SP43971119	3	12	7				
	20	SP43991115	3	3	0				
	21	SP43911066	3	3	7				
	22	SP44141049	3	7	0				
	23	SP44431052	5	20	6	10	6.25	5.1 – 7.5	0.86
	24	SP44571042	3	2	2				
	25	SP44671026	4	14	0	7	6.24	5.1 – 7.2	0.85
	26	SP44741024	5	20	3	17	6.52	5.1 – 8.0	0.79
	27	SP44940984	3	11	0	7	6.26	4.6 – 7.4	0.89
	28	SP45000979	3	0	2				
	29	SP45420975	3	0	0				
		Totals:	119	287	47	136	6.52	4.2 – 8.9	0.87
30 Nov 2002	17	SP43861191	4	13	0	}			
	26	SP44741024	5	14	0	} 9	5.05	3.9 – 6.2	0.86
30 April 2003	17	SP43861191	10	16	0	10	4.85	4.0 – 6.2	0.72
	17	SP43861191	debris	-	c.200	118	5.80	4.0 – 8.1	0.84
	26	SP44741024	10	28	0				

TABLE 3  
River Windrush: sample locations, numbers of *G. acronicus* and shell measurements

Date	Site	Grid	No. of	<i>Gyraulus acronicus</i>		Shell Diameter (mm)			
	No.	Reference	samples	Live	Shells	n	Mean	Range	$\sigma_{n-1}$
30 Nov 2002	1	SP38190672	15	1	3				
	2	SP39350578	6	11	3	}			
	3	SP39500569	4	4	8	}			
	4	SP39590564	5	11	8	}			
	5	SP40300491	4	0	18				
	6	SP39200485	7	0	3				
	7	SP40410262	5	0	2				
	8	SP40120171	5	0	2				
		Totals:	51	27	47	19	4.42	3.1 – 6.0	1.02
30 April 2003	4	SP39590564	10	56	11	37	4.57	3.2 – 6.5	0.71



TABLE 4  
River Pang: sample locations, numbers of *G. acronicus* and shell measurements

Date	Site	Grid	No. of	<i>Gyraulus acronicus</i>		Shell Diameter (mm)			
	No.	Reference	samples	Live	Shells	n	Mean	Range	n-1
11/12 July 2001	1	SU63537433	3	1	0				
	2	SU63647445	5	2	0				
	3	SU63697584	5	8	6				
	4	SU63647596	5	15	8				
		Totals:	18	26	14	24	5.50	3.9 – 6.7	0.88
30 April 2003	2	SU63647445	3	2	0				
	5	SU63747521	3	7	0				
	6	SU63787530	3	0	0				
	7		2	0	2				
	8	SU63767575	3	4	2				
	9		2	1	2				
	3	SU63697584	4	2	1				
	4	SU63647596	3	2	1				
	10		3	2	3				
	11	SU63557606	5	1	1				
	12		4	0	3				
	13	SU63217608	4	0	1				
		Totals:	39	21	16	21	5.50	3.3 – 6.9	0.87

TABLE 5  
Back Water sample locations and numbers of *G. acronicus*

Date	Site	Grid	No. of	<i>Gyraulus acronicus</i>	
	No.	Reference	samples	Live	Shells
12 July 2001	1	SU50699642	5	0	0
	2	SU50479622	8	0	0
	3	SU50069576	5	1	2
		Totals:	18	1	2

TABLE 6  
Associated molluscs in the surveyed sections of each river

Species	R. Evenlode	R. Windrush	R. Pang	Back Water
<i>Theodoxus fluviatilis</i>	x	x		
<i>Viviparus viviparus</i>				x
<i>Valvata cristata</i>	x	x	x	
<i>Valvata piscinalis</i>	x	x	x	x
<i>Potamopyrgus antipodarum</i>	x	x		x
<i>Bithynia tentaculata</i>	x	x	x	x
<i>Bithynia leachii</i>	x	x		
<i>Physa fontinalis</i>	x	x	x	x
<i>Physella acuta</i>				x
<i>Stagnicola fuscus</i>		x	x	
<i>Lymnaea stagnalis</i>	x	x	x	x
<i>Radix auricularia</i>	x			x
<i>Radix balthica</i>	x	x	x	x
<i>Planorbis carinatus</i>	x	x	x	x
<i>Anisus vortex</i>	x	x	x	x
<i>Bathyomphalus contortus</i>	x	x	x	
<i>Gyraulus acronicus</i>	x	x	x	x
<i>Gyraulus albus</i>	x	x	x	x
<i>Gyraulus crista</i>		x	x	
<i>Ancylus fluviatilis</i>	x		x	
<i>Acroloxus lacustris</i>	x	x		x
<i>Unio pictorum</i>	x			x
<i>Unio tumidus</i>	x			x
<i>Anodonta anatina</i>	x	x		x
<i>Sphaerium corneum</i>	x	x	x	x
<i>Musculium lacustre</i>		x		x
<i>Pisidium amnicum</i>	x		x	x
<i>Pisidium casertanum</i>	x	x	x	x
<i>Pisidium milium</i>	x	x	x	
<i>Pisidium subtruncatum</i>	x	x	x	x
<i>Pisidium henslowanum</i>	x	x	x	x
<i>Pisidium hibernicum</i>	x	x	x	
<i>Pisidium nitidum</i>	x	x	x	x
<i>Pisidium tenuilineatum</i>			x	
Totals:	28	26	23	25

Nomenclature follows Falkner *et al.* 2001.

TABLE 7  
Water quality data (Environment Agency monthly samples January 1990 to December 2002)

River	Pang			Evenlode			Windrush		
Location	Pangbourne			Cassington			Beard Mill		
Grid Reference	SU 63482 76353			SU 63482 76353			SP 39699 05521		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	7.67	8.6	8.09	7.5	8.5	8.09	7.66	8.5	8.2
BOD (mg/l)	1	4.7	1.21	1	7.4	1.6	1	3.1	1.09
Ammonia (mg/l)	0.03	0.5	0.039	0.03	0.22	0.04	0.03	0.15	0.027
Nitrate-N (mg/l)	5.61	14.8	8.24	4.14	10.7	6.94	5.76	9.33	7.67
Chloride Ion (mg/l)	18	67	24.6	19.6	111.7	32.34	16.7	36.6	23.14
Orthophosphate (mg/l)	0.03	0.09	0.05	0.08	0.396	0.207	0.02	0.08	0.043
Magnesium (mg/l)	2.45	10.8	3.39	3.59	5.1	4.34	3.4	5.2	4.56
Calcium (mg/l)	56	149	111.9	86	131	113.22	95	126	108.45
Copper (µg/l)	1	31.5	2.9	1.15	6.6	2.38	0.9	25	1.99
Zinc (µg/l)	2	73.1	9.13	2	25	5.81	2	59.4	5.15
Dissolved Oxygen (%sat)	77.7	135	100	75.4	187.2	95.12	75.8	122.3	100.55
Dissolved Oxygen (mg/l)	8.2	14.7	11.11	7.61	21.5	10.38	7.24	14.3	10.93
BMWP	133	231	189	110	217	165	135	187	152
ASPT	4.93	6.08	5.75	4.96	5.93	5.51	5.15	5.97	5.51
No. of invertebrate families	27	39	33	22	39	30	24	35	28

BMWP = British Monitoring Working Party score of invertebrate diversity and quality  
ASPT = Average score per taxon



## THE DATE OF PUBLICATION OF *THE NON-MARINE MOLLUSCS OF THE MALTESE ISLANDS*

There is disagreement in the literature regarding the date of publication of the monograph *The non-marine Molluscs of the Maltese Islands* by F. Giusti, G. Manganelli and P.J. Schembri. While we, the authors, have consistently cited it as published in 1995<sup>1</sup> (the date printed on the volume), some German colleagues cite it as dated 1996 (Beckmann 1997<sup>2</sup>; Boeters & Falkner 2000<sup>3</sup>; Gerber 2000<sup>4</sup>; Bank *et al.* 2001<sup>5</sup>).

Asked for an explanation, Dr G. Falkner replied that, in his and his German colleagues' opinion, the requirement of Article 8.1.2. of the International Code of Zoological Nomenclature (that a published work "must be obtainable, when first issued, free of charge or by purchase") had not been met for a 1995 date of publication. Dr Falkner reported (*in litt.*, 2 May 2001) that some German malacologists had tried to obtain the book in December 1995. They all received an essentially identical letter dated 6 December and signed Anna Grassini, Publication Dept. [Museo Regionale, Turin], which noted "The printers will give us the books hopefully by the middle of next month; so consider that you will receive your copies by the end of January [1996], if everything goes according to schedule".

To settle this matter we here set out the circumstances surrounding the publication of our work.

1) The entire print-run of 700 copies of the book had been printed by 30 November 1995, as reported on the last page of the monograph itself.

2) On 6 December 1995, the book was officially presented in Turin, at a "Forum Naturae" meeting, which took place in the Sala Giolitti of the cultural centre "Torino Incontra". The monograph was launched by the director of the Museo Regionale di Scienze Naturali di Torino, Prof. O. Bortesi, the former director of the Museo Civico di Storia Naturale di Verona, Prof. S. Ruffo, and the authors. The event was announced in the local newspapers (e.g. Repubblica, ) and was video-registered and the video is on sale at the Museo Regionale di Scienze Naturali (Turin).

3) On the occasion of the official presentation, a number of copies were distributed (some free of charge, some sold) to the members of the Società Italiana di Malacologia and to colleagues at the University of Turin who attended the presentation.

4) The letter from Mrs Grassini on 6 December (the same day as the official presentation of the volume) notified overseas customers that the remaining volumes were still in the printer's building (Stabilimento tipolitografico Silvestrelli & Cappelletto s.r.l., Via Romani 17F, 10131 Torino) and that, because of closure of the printing works over the Christmas and New Year holiday, interruption of Museum activities and uncertainty of the mail during that time, orders placed by post from abroad would not be dispatched until near the end of January 1996.

It is clear that, although there was an unfortunate delay in fulfilling overseas orders, copies of our book were, indeed, obtainable and distributed on 6 December 1995 in accord with Article 8.1.2 of the Code, and this is the correct date of publication.

<sup>1</sup>GIUSTI F., MANGANELLI G. & Schembri P.J. 1995 *Mus. reg. Sci. nat. Monogr. (Turin)* 15: 1-607.

<sup>2</sup>BECKMANN K.-H. 1997 *Heldia* 4 (Sonderheft 5): 31-34.

<sup>3</sup>BOETERS H & FALKNER G. 2000 *Heldia* 3: 37-40.

<sup>4</sup>GERBER J. 2000 *Heldia* 3: 42-44.

<sup>5</sup>BANK R.A., BOUCHET P., FALKNER G., GITTENBERGER E., HAUSDORF B., VON PROSCHWITZ T. & RIPKEN T.E.J. 2001 *Heldia* 4: 77-128.

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## CATINELLA ARENARIA (SUCCINEIDAE) LIVING IN BRITTANY, NW FRANCE

*Catinella* (Quickella) *arenaria* (Potiez & Michaud, 1835) is a rare species recorded from a few widely separated coastal and upland (including alpine) localities in western Europe. It is currently on the Red List for both France and Great Britain. Reexamination of old museum specimens by Falkner *et al.*<sup>1</sup> (2002) led to the conclusion that many old records of *C. arenaria* from France (e.g. in Baudon 1877<sup>2</sup>, Germain 1931<sup>3</sup>) were based on misidentified shells of *Succinea oblonga* (Draparnaud, 1801). The only confirmed record of *C. arenaria* was from Boulogne (Dept. Pas-de-Calais), the type locality. In addition, two records of *C. arenaria* have recently been confirmed anatomically from Dept. Hauters-Alpes at 1800 and 2300 metres elevation (Gargominy & Ripken 1999<sup>4</sup>, Falkner *et al.* 2002).

In July 2001 we found *C. arenaria* at two locations widely separated on the northern and southern coasts of Brittany. Live snails were collected near the coast just N. of Fort Bloque (W. of Lorient), Dept. Morbihan (47°44'N., 3°30'W., *ca* 5 m alt.) in a dune-slack with low vegetation (identification subsequently confirmed by dissection). One dead shell of no great age was also collected at Dunes de Keremma (N. of D10 *ca* 8 km W. of Plouescat), Dept. Finistère (48°39'N., 4°17'W., *ca* 10 m alt.) again in a dune-slack. No living *C. arenaria* were found at the latter site, but the calcareous dune-slack habitat and rounded shell mouth indicates that *C. arenaria* is involved rather than *S. oblonga*.

These localities on the northern and southern coasts of Brittany thus represent a considerable extension to the known distribution of *C. arenaria* in France, south and west of the type-locality at Boulogne.

Thanks are due to Gerhard Falkner and Dr Michael Kerney for assistance with literature.

<sup>1</sup>FALKNER G., RIPKEN T.E.J., & FALKNER M. 2002 *Mollusques continentaux de France Liste de Référence annotée et Bibliographie* Muséum National d'Histoire Naturelle-Laboratoire de biologie des invertébrés marins et de malacologie, Paris.

<sup>2</sup>BAUDON A. 1877 *Monographie des succinées françaises* JB Ballière et fils, Paris.

<sup>3</sup>GERMAIN L. 1931 *Mollusques terrestres et fluviatiles. Fauna de France* 22. Reprint 1969, Kraus-Reprint, Nedeln, Lichtenstein.

<sup>4</sup>GARGOMINY O. & RIPKEN T.E.J. 1999 *Inventaire des mollusques d'intérêt patrimonial de la région PACA Programme d'actualisation des ZNIEFF PACA* 19pp. Conservatoire Études des Écosystèmes de Provence/Alps du Sud, Aix-en-Provence & Museum National d'Histoire Naturelle, Paris.

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## MYXAS GLUTINOSA (GASTROPODA: LYMNAEIDAE) IN IRISH LAKES

*Myxas glutinosa* (Müller) has become increasingly rare in the lowlands of Europe over the last 50 years so that it is now one of Europe's most endangered freshwater molluscs<sup>1</sup>. Most populations have been lost from Britain and Ireland<sup>2</sup> and the only one known to have survived in Britain is at Bala Lake (Wales) where it was rediscovered in 1998. In Ireland *M. glutinosa* still occurs along stretches of the Grand Canal and Royal Canal near Dublin, although these populations have declined since the 1970s<sup>3, 4</sup>. A recent account suggests that its survival in Ireland may depend on protecting these populations in canals<sup>2</sup>. The reasons for the undoubtedly rapid decline of *M. glutinosa* in Europe are poorly understood, although because it is now associated with habitats which are not enriched by nutrients it seems likely that eutrophication is implicated in its demise<sup>1, 2</sup>.

During visits to Ireland between 2001 and 2003 I found six new sites with *Myxas glutinosa*, all natural lake habitats (as opposed to canals). These included four new vice-county records.

The locations of the new finds and a brief description of the habitats follows:

**13 August 2001, N43-85-, Lough Sheelin, Co. Cavan (vice-county H30):** *Myxas glutinosa* was abundant at this marl lake which is used for leisure activities such as fishing and boating. Many were seen crawling on marl-covered stones, and on debris (tyres, wood, etc.) in shallow water around a small jetty on the north shore. Others were seen floating at and just below the water surface. The individuals were all of adult size. Much of the water surface was covered by an algal bloom.

**26 May 2003, M12-59-, small pool by Lough Mask, Co. Mayo (H26):** This is a relatively small pool occurring within an extensive area of flat-bedded limestone pavement close to the edge of Lough Mask. Two adults were seen (through the surface of the shallow water) crawling on the marl and mud sediments.

**14 Oct. 2003, M12-59-, Lough Mask, Co. Mayo (H26):** *Myxas glutinosa* was abundant, and although individuals were variable in size they were mainly small and immature. Large numbers were obtained by dragging a small 'kitchen' sieve through submerged vegetation of charophytes (20+ in each sample) and many were also seen crawling on the surface of the sediments (deep fine mud and marl). *M. glutinosa* was not found at this locality (despite sampling for molluscs) during an earlier visit in May 2003 when it was found at the small pool described above.

**16 May 2003, G21-03-, Lough Cullin, Co. Mayo (H27):** *Myxas glutinosa* was common and many adults were seen crawling on the surface of rocks in shallow water around a 'headland' of flat-bedded rock. However, its occurrence appeared to be localised and none were found in the bays nearby. None could be found here during a search (for approximately one hour) on 19 July 2003. However, at that time it was raining and very windy so that waves made it difficult to search effectively. During a third visit in October 2003, small (immature) and a few larger (nearly adult) *M. glutinosa* were found crawling on the surface of rocks, on the soft marl and other fine sediments, and under rocks.

**14 Oct. 2003, M09-57-, Lough Mask, Co. Galway (H16):** *Myxas glutinosa* was apparently uncommon at this locality. Five small (immature) snails were found in shallow water crawling on the surface of deep mud and marl sediments near a small jetty. However, searching at this location was difficult because of the deep soft sediments limiting access.

**17 Oct. 2003, M06-58-, Lough Mask, Co. Galway (H16):** *Myxas glutinosa* was abundant and the most common of all the Lymnaeidae recorded. Although variable in size, all



were clearly immature. Large numbers were obtained by dragging a small sieve through the submerged charophyte vegetation. In addition many were seen crawling on the mud sediment and on the surface of stones and debris; others were found on the under-surfaces and sides of stones lifted from the water. Many *M. glutinosa* were found in shallow water, e.g. on the sides of partly submerged stones in water of *ca* 7 cm depth.

To summarise, in these new lake habitats in Ireland *M. glutinosa* was found on soft marl and mud sediments, on vegetation and on hard rock surfaces. This apparently differs from the canal habitats in Ireland where it is 'typically found on stones or on the masonry of locks and bridges rather than on the vegetation'<sup>2</sup>. Thus it would appear that *M. glutinosa* in Ireland may tolerate varied substrata as shown in other studies<sup>5, 6</sup>.

It is noteworthy that *M. glutinosa* was not found in Lough Mask in May 2003 at a time when it was found in a small pool 200 m away. However, on a subsequent visit in October 2003 the water in Lough Mask had fallen by at least one metre and *M. glutinosa* was found to be abundant. Hence, in retrospect it seems likely that *M. glutinosa* had been overlooked in May 2003 because the lake bottom was inaccessible. It thus seems highly likely that searches at other localities on L. Mask during May 2003 may have been unproductive due to the high water level. Stelfox<sup>6</sup> suggested that during the summer months *M. glutinosa* may be overlooked because it remained in the deeper parts of its habitats. It seems more likely however, that *M. glutinosa* occurs in a depth-zone within some lakes which only becomes easily accessible, (using some sampling techniques) when the water levels are low.

The abundance of predominantly immature snails in October 2003 compared with large numbers of adults in May 2003 and August 2001 may imply seasonality in the life-cycle of *M. glutinosa* in Ireland, but more sustained and systematic observations will be needed to check this. Boycott<sup>5</sup> long ago suggested that *M. glutinosa* may have been overlooked to some extent in Britain because it is absent or very immature in the mid-summer holiday period, whereas in these lakes in Ireland mature *M. glutinosa* were recorded during May and August. It may be that the species has a different life-cycle in Ireland or that there are both summer and winter generations occurring, as in Poland<sup>1</sup>.

There are very many lakes (and pools) with calcareous substrata in the limestone districts of Ireland. It seems likely that further surveys targeting similar natural habitats would reveal additional populations. At any event, it is evident that populations have been overlooked in Ireland, resulting in an unduly narrow interpretation of its habitat requirements and conservation needs there, where it was thought that its survival may depend on protecting the canal sites <sup>2</sup>.

<sup>1</sup>Whitfield M. *et al.* 1998 *J. Conch. Special Publication* 2: 209-221.

<sup>2</sup>Kerney M.P. 1999 *Atlas of the land and freshwater molluscs of Britain and Ireland* Harley Books, Colchester.

<sup>3</sup>Biggs J. & Williams P. 2002 *J. Conch.* 37: 579.

<sup>4</sup>Moorkens E. 2003 *Moll. World* 2: 6.

<sup>5</sup>Boycott A.E. 1936 *J. Anim. Ecol.* 5: 116-186.

<sup>6</sup>Stelfox A.W. (1911) *Proc. R. Ir. Acad.* 29(B): 65-164.

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## TRUNCATELLA SUBCYLINDRICA - A NEW SHELL RECORD FOR THE CHANNEL ISLANDS.

During a visit to Jersey in September 2003 a sample of shell sand was collected from the western end of St. Aubin's Bay Jersey : location 6 of the 1998 Field Meeting in Jersey<sup>1</sup>. Processing the sample after returning home produced one dead shell of *Truncatella subcylindrica*.

Distribution of this species in the U.K. is restricted to the Solent Area<sup>2</sup> and St. Mawes Bay<sup>3</sup>. It also occurs in Europe and so a find in the Channel Islands is not that surprising, situated as they are some 112 kms SSW of the Solent and, for Jersey, only 32 kms off the French coast.

The shell sand sample when collected did not appear to be very exciting and, as already indicated, the shell was not found until after leaving Jersey. No attempt was therefore made to examine the area in detail and try and locate live material.

St Aubin's Bay is some 4 kms. wide, stretching from St Helier in the east to St Aubin in the west. At low tide a wide expanse of sand is exposed right across the bay. At HWST at the western end the sea comes right up to a sea wall constructed of large granite blocks. I am not sure whether the same applies at the eastern end of the bay or whether there might be a suitable shingle habitat above high water mark. The species has been reported living between unmortared but firmly embedded slabs that form sea walls<sup>2</sup> so this could be another possibility in the search for live material.

The shell sand sample was collected from strandings at the top of the spring tide mark at the western extremity of the bay. The strandings were only evident for some 50 metres along the beach. Large Foraminifera and small fragments of coal bulked out the 300 ml. sample which nevertheless produced some 40 species of mollusc.

Amongst these species, one of particular interest was *Paludinella littorina* where again only one dead shell was found. In the Jersey Field Meeting Report of 1998 this species was reported from two sites, Flicquet Bay under large upper shore slabs, and in a cave on the north west corner of the island. For the moment, the Fleet in Dorset is the only site in Britain where *Truncatella* and *Paludinella* are reported as co occurring<sup>4</sup>. It would be interesting to conjecture that there might be a second such site nearby.

The shell sand sample was collected after an extensive period of quiet weather and most of the shells including the *Truncatella*, were in poor condition, with no live material present. Worn shells may indicate some degree of post-mortem transport, however, the relative isolation of Jersey (and the Channel Islands) is good evidence for a local provenance for the *Truncatella* shell. Hopefully this record will stimulate further research to seek an established colony of this rarely recorded species nearby, and perhaps also on Guernsey and the other Channel Islands where there is suitable habitat.

My thanks to Jan Light who kindly confirmed identification of *Truncatella* and *Paludinella*.

<sup>1</sup>Killeen I.J. 1998 Conchologists Newsletter 149 168-171

<sup>2</sup>Light J.M. and Killeen I.J. 2000 In: Collins M. & Ansell K (eds). *Solent Science - A Review. Proceedings in Marine Science* (1). Elsevier, Amsterdam. pp 295-298.

<sup>3</sup>Killeen I.J. and Light J.M. 1998 *Journal of Conchology* 36(4): 50-51.

<sup>4</sup>Killeen I.J. and Light J.M. 2002 *Journal of Conchology* 37(5): 556.

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## VERTIGO MOULINSIANA IN THE UPPER VALLEY OF THE SOMME RIVER (NORTHERN FRANCE)

Since Germain (1931)<sup>1</sup>, there have been no new records of Desmoulin's Whorl Snail, *Vertigo moulinsiana* (Dupuy, 1849) within the department of Aisne in northern France. Recently (2003), two populations of the Desmoulin's Whorl Snail were found in the upper valley of the Somme River. The first population is located in the Marais d'Isle Natural Reserve in Saint-Quentin. The second one is situated in the commune of Courcelles, ten kilometres North-East from Saint-Quentin.

In the Marais d'Isle Natural Reserve, the Desmoulin's Whorl Snail was observed in belts of sedges communities dominated by *Carex acutiformis*, around ponds. The soil is composed by recent alluviums of the River Somme with inclusions of peat. *Vertigo moulinsiana* was also found in an old poplar grove. When poplars were presents, there were no plants communities under the trees. Where poplars have been cut, the place was colonized by typical plants communities of recent mud dominated by *Ranunculus sceleratus*. Afterwards, the place was colonized by high plants communities dominated by *Carex acutiformis*, *Carex riparia*, *Epilobium* sp., etc. *V. moulinsiana* was found on leaves of *Carex acutiformis* and *Carex riparia*. This record is particularly interesting for two reasons:

Firstly, populations of this snail are located in a reserve situated in the heart of the town of Saint-Quentin (approx 60.000 inhabitants). Secondly, this occurrence in a place recently disturbed (the site was an old poplar grove till the year 2001) refutes the generally accepted idea that *Vertigo moulinsiana* is restricted to old wetlands (Kerney 1999)<sup>2</sup>. We believe that the colonization of this place by Desmoulin's Whorl Snail may have been facilitated by muskrat (*Ondatra zibethicus*). It is also unusual to find populations of the species located, as the second population from Courcelles is, because it is situated just two kilometres from the spring of the Somme River. Usually *V. moulinsiana* is restricted to lowland parts of rivers in northern France (personal observations). More research will be carried out to precise the distribution of this snail in the Upper Somme Valley.

<sup>1</sup>Germain L. 1931 *Mollusques terrestres et aquatiques* (première partie). Faune de France. Paul Lechevalier.

<sup>2</sup>Kerney M.P. 1999 *Atlas of the land and freshwater molluscs of Britain and Ireland*. Harley Books.

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## LEIOSTYLA ANGLICA (WOOD, 1828) LIVING IN NORTHERN FRANCE

In 1905, Margier<sup>1</sup> made the first mention of *Leiostyla anglica* in France. The snail was collected in Isle of Ré. Since this date, the species has not been found there again although specific search, and the occurrence of *Leiostyla anglica* in France was then considered as doubtful (Falkner *et al.*, 2002)<sup>2</sup>. However it was cited from the isle of Guernsey (Kerney 1999)<sup>3</sup>.

Recently a small population of *Leiostyla anglica* has been discovered in northern France, in National Forest of Ecault, located in the commune of Ecault in the département of Pas-de-calais (UTM DS 01). It was found among moist leaf litter of an oak-ash wood growing in a sand dune. The plant community is composed of many species which indicate a meso-eutrophic and calcareous humus (e.g. *Hedera helix*, *Geum urbanum*, *Glechoma hederacea*). Amongst other mollusc species found in syntopy with *Leiostyla anglica* are *Zenobiella subrufescens*, *Acanthinula aculeata* and *Aegopinella pura*.

In its British localities, *Leiostyla anglica* is found amongst moss and leaves on damp ground in woodland with under-storey of herbs and sedges (Kerney & Cameron 1979)<sup>4</sup>. However we have not enough information about the species in northern France to define precisely its habitat. More research will be carried out to precise the habitat and the distribution of *L. anglica* in this region.

<sup>1</sup>Margier E. 1905 titre ? *Feuille jeunes Natural*. 35: 68-78.

<sup>2</sup>Falkner G., Ripken T.E.J. & Falkner M. 2002 Mollusques continentaux de France. *Patrimoine Naturel*. 52: 1-350.

<sup>3</sup>Kerney M. 1999 *Atlas of land and Freshwater Molluscs of Britain and Ireland*. Harley Books, Colchester. 264p.

<sup>4</sup>Kerney M. & Cameron R.A.D 1979 *A field guide to the land snails of Britain and north-west Europe*. Collins, London. 288p.

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## BOOK REVIEW

*Indian Seashells Part 1 Polyplacora and Gastropoda* by R.V. Subba Rao. 2003 Zoological Survey of India. Occasional paper No 192 pp 416 £40 ISBN 81-85874-72-7.

The Subcontinent of India with its long and varied coastline and associated offshore islands - Andamans, Nicobars and Lakshapweep - has a large and interesting molluscan fauna. Some 3271 marine species are recorded from India, of which this book deals with some 530 species, so even allowing that the book solely deals with Gastropoda and Chitons, it can be seen that this is by no means a comprehensive coverage. On the whole this work is restricted to the larger species most likely to be encountered by the local students, for whom the book is, presumably, primarily intended. Unfortunately, from the point of view of a general collector, these are the species most likely to be covered in existing guide books to tropical marine shells.

Introductory sections of the book cover the general biology and ecology of marine molluscs, and their economic importance, with some very interesting information on local fisheries. The bulk of the book is given over to a systematic account, within this for each family more detailed accounts of biology and ecology of the family is given followed by clear descriptions of each species. These also give useful detailed information on distributions within India, as well as general notes on wider distributions, helpful comparisons are made between similar species. Each family section is concluded with a selective bibliography relating to the family - locally published papers as well as more general taxonomic works. It is somewhat frustrating that there is often a space after the selective bibliography where additional species in the family could, if not treated in depth, have been simply listed. Referring to the Naticidae for example we are told that "about 25 species were reported from India but only the following 22 are dealt with here" yet the section ends with a blank half page where the additional species could easily have been listed. This is all the more irritating when additional species lists have in fact been given for a few families - *Conus*, *Turridae* and *Cerithiidae*.

The nomenclature used is sometimes a little confused, for example *Muricanthus virgineus* (Roeding, 1798) on page 231 should be *Chicoreus virgineus* - which is actually referred to on page 40. Out of 29 species of *Cypraea* covered 28 are placed in various subgenera yet one is unaccountably listed as simply *Cypraea*. Under *Babylonia spirata* we read "the record from Andamans is based on one old specimen labelled *Eburnea ambulacrum* ... its occurrence in the Islands is doubtful" and *Eburnea ambulacrum* is a valid species, so regardless of whether this is a dubious locality record or a misidentification it should not have been quoted as a synonym.

Each species covered is illustrated using some 96 photographic plates, mostly black and white, but with 10 rather poorer quality colour plates. On many of the plates scale bars are used by the specimens but without giving any indication of the scales used. Similarly reference numbers are quoted for many specimens illustrated, including a couple of type specimens, but without an indication of which collection these are from, although it is presumably the Zoological Survey of India Collection. I would also query the selection of species for some of the few colour plates. Why devote one plate to two specimens of *Cassis cornuta* and two specimens of *Phalium glaucum*, especially when the former appears in colour on the front cover. Completing the book are a glossary, an index and a general bibliography with a comprehensive list of regional works together with more general identification books.

The book contains numerous misprints, a two page list of corrections is included as a supplement, and this could easily be extended. I would also query the identification on page 241 of *Nassa sarta*, which is a Pacific species, the species described and illustrated

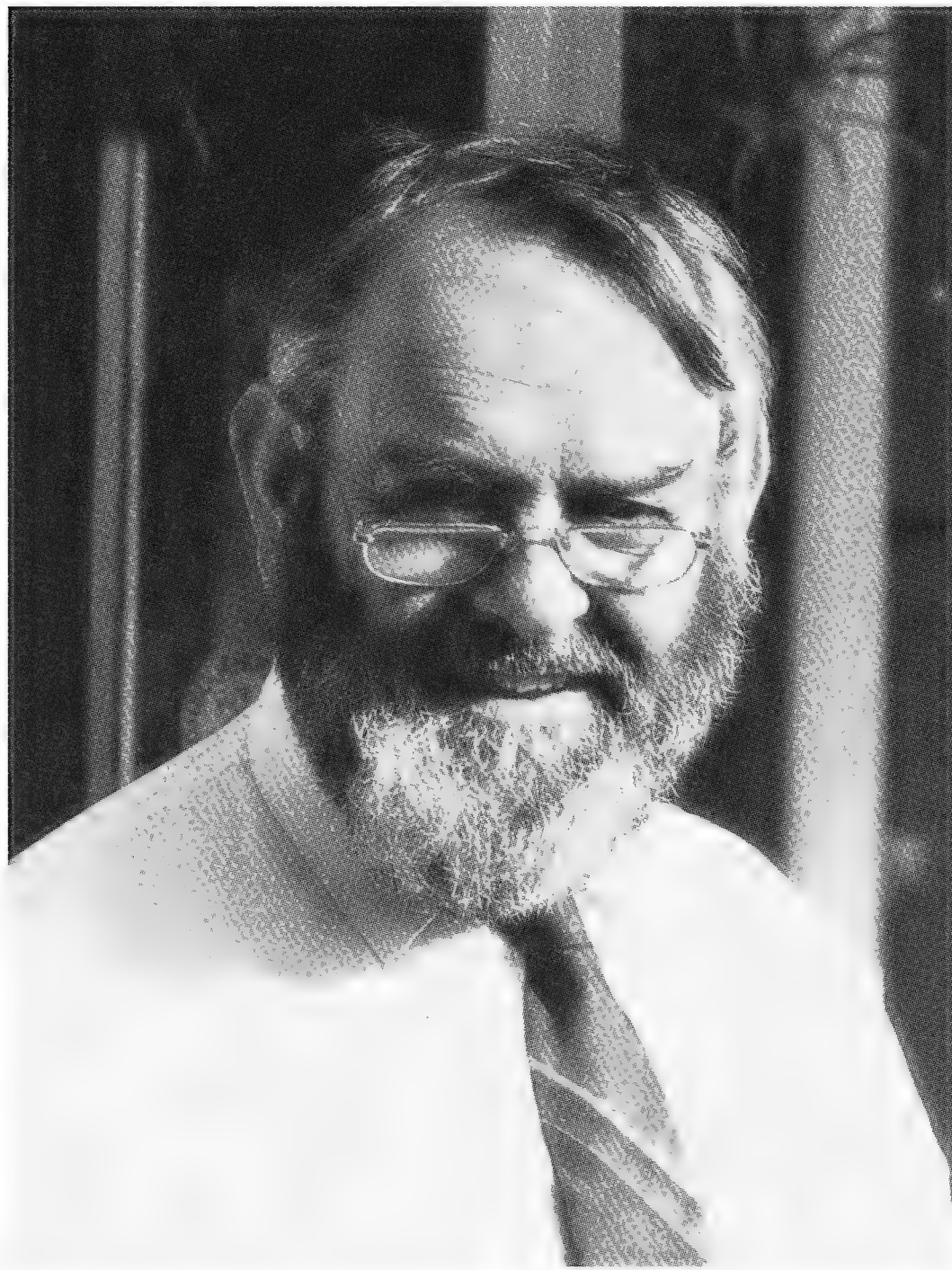
is surely the Indian Ocean *Nassa francolina*.

Despite its failings, this book is undoubtedly the most comprehensive work available on Indian Marine Gastropoda and Chitons, and hopefully it will do much to stimulate the study of shells in India. It will certainly be essential to anybody working specifically on Indian shells, and offers much for the more general collector. At such a modest price, especially for a hardback, this should be on the shelves of every serious conchologist. A companion publication dealing with the bivalves and other remaining classes will, it is to be hoped, follow to complete the work began with this volume.

Kevin Brown



## OBITUARY: DAVID HEPPELL (1937-2004)



David Heppell, a member of the Conchological Society since 1959, has died, in his 67<sup>th</sup> year. Born at Gosport in Hampshire on 21<sup>st</sup> November 1937, he was the eldest of three children, his two sisters, Carole and Janet, surviving him. As a child David was blessed with an inquiring mind and a determination to get to the bottom of things, collecting and studying postage stamps, books, fossils, insects, shells, and anything puzzling or odd. Indeed, he delighted in all things strange or unexplained. Words fascinated him and he came to attach great importance to their meanings and correct usage. He developed a skill at card games, such as Bridge and Whist, and became a good chess player. Such interests and skills may have distanced him from his schoolfellows. Even as an adult he seems to have regarded himself as an outsider. He once told his friend and colleague of many years standing, Geoff Swinney, 'that he always felt something of a loner and that he had few friends'.

After leaving school he studied dentistry at University College, London, from 1956 to 1961. Having qualified as a dentist, he joined the School Dental Service. Realising that examining other persons' teeth was not to his liking, he resigned after about six months. On the other hand, malacology was to his liking. Having investigated the presence on the Hampshire coast of *Mercenaria mercenaria* (L. 1758), he published his first article on molluscs in his school magazine (Heppell, 1957). He followed this up four years later with a more comprehensive article on this introduced species in our journal (Heppell, 1961b). By then David had made my acquaintance, occasionally visiting me at the Natural History Museum where I had been working since 1957. We became friends and met frequently, the skating rink at nearby Bayswater being a favourite venue. Although there was never any doubt that his preferred forms of exercise were cerebral, he donned his skates regularly and attempted, doggedly and usually unsuccessfully, to stay upright on them. His watchword, from the beginning to the very end, was determination.

David's chance to become professionally involved with molluscs and their shells came about in an unlikely way in 1962. I had been approached by the Linnean Society of London to overhaul and write a report upon the Linnaean shell collection, then in a sorry state. Having accepted that it would take a year to achieve this objective satisfactorily, the Linnean Society agreed to award a grant to David for that length of time. The grant was to pay him for doing my job in the Natural History Museum, the museum continuing to pay me my normal salary. He filled my shoes efficiently, but his list of publications suggests that he may have spent a certain amount of his time investigating things that were not part of his remit.

In 1963, after filling my shoes for a year, he had the opportunity to do three years

postgraduate research at the University of Glasgow, under the watchful eye of the distinguished marine biologist Professor C. M. Yonge. His research topic was 'A comparative anatomical and ecological study of European Cardiacea'. The research involved was not to his liking, however, and he never submitted his thesis. In any case, having already acquired first-hand experience of museum work, he had joined the Royal Scottish Museum in Edinburgh as a Senior Research Fellow in October 1966, ostensibly 'to study taxonomy of the Mollusca with particular reference to the Amphineura, and also to continue his revision of the list of British Marine Mollusca and to prepare a report on the Mollusca of the Celtic Sea.' (I. Finlay, *Report on the Royal Scottish Museum for the year 1966*). How well he fulfilled these objectives is not for me to say, but another glance at his list of publications suggests that he may have been distracted by the study of zoological nomenclature. For the rest of his working life, indeed, he was involved with the labyrinthine ramifications of this study, not just as an academic exercise, but as a professional occupation. For some years he was a Commissioner on the board of the International Commission of Zoological Nomenclature, his expertise being acknowledged by all who benefited from it. Undoubtedly, that expertise was founded on his intense love of words.

Circumstances beyond his control may have prevented him from becoming a model curator, but organising molluscan shells would not have given him the same satisfaction as organising words anyway. Nevertheless, that he made a valiant effort to succeed in a difficult job is clear from a CV he prepared for himself. 'I have had to design and set up a Mollusca Section from scratch,' it reads, 'devise storage and documentation systems, work out a policy for acquisitions, field work and display, and train staff.' More a closet naturalist than a field worker, he made relatively few excursions into the great outdoors in search of molluscs. Those he made were probably more rewarding socially than productive materially. Delving into the mysteries of molluscan anatomy was not his forte, either, so he may have surprised everyone when he attempted, with some success, to dissect a large squid in his office. Never happier than when poring over books, his preferred environment was a library, a well-filled one being always available to him at home. There were occasions, however, when a particular research project demanded his presence elsewhere. He travelled to the Indian sub-continent in 1982 and 1984, each time accompanied by his third wife, Frances, with the object of investigating the present state of the chank industry. Working under sometimes difficult conditions, he observed the many different aspects of an activity few westerners have bothered to investigate. A tangible result of his studies was the excellent exhibit about the chank (*Turbinella pyrum*) he prepared for his museum. Unfortunately, he never published an account of his work on this influential gastropod.

David was prepared to go to extraordinary lengths in his research before deciding he could go no further, tenaciously following up obscure references, never afraid to contact leading authorities for their personal views. Nowhere is this more apparent than in his lengthy article dealing with the early history of malacology (Heppell, 1995g). The notes and bibliography at the end of this excellent piece of work, occupying as much space as the main text, are not meant to be passed over unread! When I was engaged to write a series of six books on Classic Natural History Prints it was to David I turned for help with the volume dealing with molluscs and their shells. The volume we co-authored (Dance & Heppell, 1991) is easily the best of the series. Billed by the book trade as 'a modern rarity', it has also become virtually unobtainable, a tribute to David's logical approach to the subject.

He was very interested in the nature of error and how errors are perpetuated, collecting information about animals or disconnected parts of animals which have been misidentified as molluscs or vice versa. The subject of pseudoconchology had long interested me, too, and having collected many examples, we had intended to



publish our conclusions about them in a small book. Latterly, David became deeply involved with cryptozoology. Having previously helped me with my book *Animal Fakes & Frauds* (1976), he continued to share information with me on curious creatures, real and imagined. We had hoped to co-author a book about horned hares and he had hoped to write something substantial about mermaids. Death intervened before any of these projects could be realised.

The International Commission on Zoological Nomenclature was not the only organisation to benefit from David's abilities. As Editor he produced seven numbers of *The Journal of Conchology* from December 1965 to October 1968. He also helped to launch the Porcupine Society, an organisation formed for the purpose of studying marine molluscs and other life forms in the northern parts of the United Kingdom. In 1986 he took on the organisation of the Ninth International Malacological Congress, almost single-handedly. Held in Edinburgh from 31 August to 6 September 1986, the Congress achieved an unqualified success, an achievement the more remarkable as Frances had timed the arrival of their son, Sam, to coincide with the event! A few years later, under less pressing circumstances, she produced a girl, Sophie. The two children, acquired relatively late, brought David great happiness and he delighted in following their progress through life. Having retired from his museum job, he agreed to a proposal by Frances, a Canadian citizen, that the four of them move to British Columbia, where she had spent her childhood. The move was realised in 1998, when the family moved into the property at Gibson's Landing, Vancouver, vacated for them by Frances' parents.

Having settled in to his Canadian home, David resumed his interests, especially philately. Both he and Sam had entered competitions as members of the Edinburgh Philatelic Society, David becoming a member of the India Study Circle in 1995. Now, what had been a part-time hobby became an obsession. David joined the South Asia Philatelic Study Group of the Pacific Northwest and was soon making original contributions to the study of the postal history of the Indian sub-continent, including 'A Key to the "Conch Shell" Issues of Travancore'. Regrettably, his health began to be undermined by a blood disorder and he declined rapidly. He died on Saturday, 24 April 2004, mentally alert and cheerful to the end. A commemoration of his life and achievements was held near his Canadian home on Sunday, 6 June 2004, attended by a large assembly of friends and relatives. I was privileged to take part in this moving event which proved that David was quite wrong to think he had few friends. He had many, including those who asked for his professional advice, those who benefited from his expertise, and those who, like me, marvelled at the way he gave freely and generously of his time, asking for no reward - the rarest gift of true friendship. A loner, perhaps: friendless, certainly not. David Hurd's sensitive portrait shows the dual personality of its subject, the convivial smile suggesting a man at ease with the world, the direct gaze a man eternally searching for the meaning of things. Maybe that is how David Heppell would have liked to be remembered.

Peter Dance



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## CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

### REPORT OF THE COUNCIL 2003

#### *Council Positions*

Mrs Light began her first year as President of the Society. The following Society Officers were elected: Hon. General Secretary Miss R E Hill, Hon. Treasurer Mr P U Buckle, Hon. Membership Secretary Mr M D Weideli, Hon. Editor (Journal) Dr P G Oliver, Hon. Editor (Mollusc World) Mr I J Killeen, Hon. Marine Recorder Mrs J M Light, Hon. Non-Marine Recorder Mrs G A Holyoak, Hon. Conservation Officer Dr M J Willing and Hon. Programme Secretary Mr R Boyce. New Ordinary members of Council were Mrs A J Millar, Ms J E Reynolds and Mrs C M Street. Dr D C Aldridge, Mr J E Llewellyn-Jones and Dr M B Seddon began their second year and Mr P Dansey and Miss E F A Fogan began their third year. Dr A T Sumner was co-opted to promote the interests of Conchology and the Society in Scotland.

#### *Publications*

One issue of the Journal of Conchology (Volume 38: 1) and three issues of Mollusc World (Numbers 1-3, March, July and November) were published. The Society also published the Annual Programme Card and the Members' Guide. The Society website [www.conchsoc.org](http://www.conchsoc.org) was updated and expanded.

#### *Society Display Boards*

Opportunities for the use of the Society display boards did not arise during the course of the year.

#### *Other Council Matters*

Six Council meetings (including one double length one) were held in a very busy year. Amongst the issues considered by Council were: the development of a Business Plan, Health and Safety policy, Society Insurance, encouraging junior members, regional representation of the Society, the remit of the Conservation Committee, Biological Recording policy, publication of a monograph on the contribution of Marshall to marine conchology, the appointment of a Projects Coordinator, and revision of the structure of Ordinary meetings. In more detail, the Society Business Plan (renamed the Society Action Plan) includes sections on Society Activities; recruitment of new members; recording projects on the status of *Phenacolimax* major in the UK, the distribution of *Malacolimax tenellus*, monitoring the spread of *Hygromia cinctella* in gardens, a national garden survey of molluscs, the distribution of *Crepidula fornicata*, monitoring the eastern limit of *Osilinus lineatus*; publications projects including setting up an image library, and publishing the Proceedings of the conservation symposium held at the 2001 Vienna conference; training the next generation of conchologists; meetings and Society administration/rules. A formal Health and Safety policy, including an appendix on the duties of field meeting leaders, was produced and has been incorporated into the Members' Guide. Risk assessment forms were also produced. A policy of setting up Society representatives in the regions has been partially implemented, including a Society meeting in Scotland to cater for members in that area. The structure of Ordinary meetings has been updated so that the amount of time spent on Society routine administration is reduced. The wording of the Society Action Plan has not yet been finalised, but this has not prevented some of the projects from starting, and in particular



a lot of effort has gone into the planning of a meeting for young people kindly hosted by the National Museums and Galleries of Wales, Cardiff for March 2004. No Research Grants were awarded.

I would like to thank all members of Council for their contributions during the year, especially those members who produced or contributed to the Business Plan, the Health and Safety documentation and all other proposals or papers which were circulated in advance to Council members and enabled a lot more business to be covered in the Council meetings than would otherwise have been possible in the time available.

Rosemary Hill  
Hon. Secretary

## PROGRAMME SECRETARY'S REPORT - APRIL 2004

The programme for 2003 consisted of six indoor meetings held at the Natural History Museum in London, eight field meetings and one indoor workshop.

Lectures at indoor meetings were given by Anna McIvor (Freshwater mussels as biofilters of algae), Adrian Rundle (Presidential Address: Marine Mollusca in microfossil samples - some special examples), Paul Elliott (The zebra mussel in Britain - biology, impacts and control), Dave Clarke and Trevor Coote (Current developments in the conservation programme for Polynesian tree snails at London Zoo), Jan Light and Ian Killeen (Molluscs in the modern day culture of Rodrigues), and John Llewellyn-Jones (Mother-of-pearl molluscs, how they are worked and uses).

Field meetings were held at the following venues: Blockley Quarry, Gloucestershire (fossil meeting, Leader: David Long), Hampshire hangers near Selborne (Leader: Terry Wimbleton), Isle of Arran, Scotland (marine meeting, Leader: William Penrice), Old Sulehay, Northamptonshire (Leader: Brian Eversham), Teme valley near Knightwick, Worcestershire (Leader: Harry Green), Winnall Moors, Winchester, Hampshire (Leader: Martin Willing), Exmouth area, Devon (marine meeting, Leader: Janet Sawyer), and Ightham Mote, Kent (Leader: Ron Carr).

The Society's seventeenth Molluscan Workshop was on the subject of Dog's Bay shell sand, held at Judith Nelson's home in Woking, Surrey (tutor Adrian Rundle).

The Society is grateful to all those people who contributed to the above programme, as speakers, field meeting leaders, and meeting and workshop organisers and tutors.

Ron Boyce  
Hon. Programme Secretary

# FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2003

## Statement of Financial Activities

	Note	2003	2002
<b><u>Incoming resources</u></b>			
Fees and subscriptions		£10,411	£9,820
Investment income	1	£5,454	£6,448
Income from activities for generating funds		£474	£535
Other incoming resources		£38	£0
Donations and legacies		£50	£98
<b>Total incoming resources</b>		<b>£16,427</b>	<b>£16,901</b>
<b><u>Expenditure</u></b>			
Publications costs		£18,504	£15,147
Stationery and postage		£1,347	£1,070
Meetings costs		£1,705	£874
Sundry expenses and fees		£544	£697
Grants	2	£0	£2,600
Depreciation		£600	£600
<b>Total expenditure</b>		<b>£22,700</b>	<b>£20,988</b>
<b>Net incoming/(outgoing) resources</b>		<b>(£6,273)</b>	<b>(£4,087)</b>
<b>Gains / (Losses) on revaluation</b>		<b>£2,074</b>	<b>(£3,916)</b>
<b>Net movement in funds</b>		<b>(£4,199)</b>	<b>(£8,003)</b>
<b>Fund balances brought forward</b>		<b>£111,222</b>	<b>£119,225</b>
<b>Fund balances carried forward</b>		<b>£107,023</b>	<b>£111,222</b>

## Balance Sheet at 31<sup>st</sup> December 2003

		2003	2002
<b><u>Fixed Assets</u></b>			
Tangible assets	3	£0	£600
Investments at market value	4	£78,983	£76,909
<b>Total fixed assets</b>		<b>£78,983</b>	<b>£77,509</b>
<b><u>Current Assets</u></b>			
Debtors	5	£635	£804
Cash at bank and in hand		£35,013	£41,335
<b>Total current assets</b>		<b>£35,648</b>	<b>£42,139</b>
<b><u>Short term creditors</u></b>	6	<b>£7,297</b>	<b>£8,130</b>
<b>Net current assets/(liabilities)</b>		<b>£28,351</b>	<b>£34,000</b>
<b>Total assets less current liabilities</b>		<b>£107,334</b>	<b>£111,518</b>
<b><u>Provisions for liabilities</u></b>	7	<b>£311</b>	<b>£296</b>
<b>Net assets</b>		<b>£107,023</b>	<b>£111,222</b>
<b><u>Unrestricted income funds</u></b>		<b>£107,023</b>	<b>£111,222</b>
<b>Total funds</b>		<b>£107,023</b>	<b>£111,222</b>



NOTES TO THE FINANCIAL STATEMENTS

ACCOUNTING POLICIES

General

- These statements have been prepared in accordance with Financial Reporting Standard for Smaller Entities (FRSSE) and the Charities SORP (Statement of Recommended Practice)
- Investments are valued at market value on 31<sup>st</sup> December.
- No trustee has received any remuneration during the current or previous year. Expenses incurred on behalf of the Society have been reimbursed.

Funds

- All Society funds are unrestricted funds
- The Life Membership Fund has been incorporated in the general funds, as it is an unrestricted fund. This is in accordance with the Charities SORP
- The accounts include transactions, assets and liabilities for which the Charity can be held liable.

<b>Note 1. Investment income from:</b>	<b>2003</b>	<b>2002</b>
Stock listed on recognised stock exchange	£5,127	£6,087
National Savings Income Bond	<u>£327</u>	<u>£361</u>
Total	<u>£5,454</u>	<u>£6,448</u>

<b>Note 2. Grants awarded:</b>	<b>2003</b>	<b>2002</b>
No suitable applications received for 2003	£0	
“Slime Exhibition” (2002)		£600
Research grants to 5 individuals (2002)		<u>£2,000</u>
		<u>£2,600</u>

<b>Note 3. Tangible fixed assets:</b>		
Cost of computer		£3,000
Depreciation on straight line basis over 5 years		
Accumulated depreciation brought forward		£2,400
Charge for the year		£600
Balance of depreciation carried forward		£3,000
Net book value carried forward		£0

<b>Note 4. Investments:</b>	<b>2003</b>	<b>2002</b>
Market value at beginning of year	£76,909	£84,521
Add: additions at cost	£37,472	
Less: carrying value of investments sold	(£41,168)	
Net gain/(loss) on revaluation	<u>£2,074</u>	<u>(£3,916)</u>
Market value at end of year	<u>£78,983</u>	<u>£76,909</u>

<b>Note 5. Analysis of debtors:</b>	<b>2003</b>	<b>2002</b>
Tax debtors	£635	£804
Other debtors	<u>£0</u>	<u>£0</u>
Total	<u>£635</u>	<u>£804</u>

<b>Note 6. Analysis of creditors and accruals:</b>	<b>2003</b>	<b>2002</b>
Publications accruals	£4,146	£4,525

Meetings costs	£1,900	£2,400
Subscriptions in advance	<u>£1,251</u>	<u>£1,205</u>
Total	<u>£7,297</u>	<u>£8,130</u>

<b>Note 7. Provision for liabilities:</b>	<b>2003</b>	<b>2002</b>
Marine fieldwork provision	<u>£311</u>	<u>£296</u>
Total	<u>£311</u>	<u>£296</u>

Pryce Buckle  
Honorary Treasurer

N. Light  
Honorary Examiner

## RECORDER'S REPORT: NON-MARINE MOLLUSCA

The following new vice-county records have been confirmed since the last Report (*J. Conch.* 38: 201-202, 2004). Unless stated otherwise all were confirmed from specimens collected during 2003. For continuity nomenclature follows Kerney (1999) pending a revision of the list of the land and freshwater molluscs of Great Britain and Ireland which is in preparation.

**West Cornwall** (1): *Physa acuta* seg., Tresco, Isles of Scilly (SV8914), G.A. Holyoak, det. D.T. Holyoak; *Lymnaea fuscus*, Penhale (SW7756), G.A. Holyoak, 2001, det. D.T. Holyoak, 2003; *Gyraulus laevis*, Varfell Farm Pond (SW5032), H.M. Meredith; *Lehmannia valentiana*, Tuckingmill (SW6540), G.A. Holyoak, 2001, det. R. Anderson, 2003 (animals all aphyllous or hemiphyllous).

**East Cornwall** (2): *Physa acuta* seg., Goss Moor NNR (SW9459), G.A. Holyoak, 2002, det. D.T. Holyoak, conf. R. Anderson, 2003; *Lymnaea fuscus*, Goss Moor NNR (SW9460), G.A. Holyoak, 2002, det. D.T. Holyoak, 2003; *Limax flavus*, W. of Polson Bridge (SX3584) D.T. Holyoak, 2000; *Lehmannia valentiana*, Pentireglaze (SW9471), 2001, G.A. Holyoak, det. D.T. Holyoak, 2003 (animals all aphyllous or hemiphyllous); *Anodonta cygnea*, Retallack, SW. of Wadebridge (SW9365), N. Barrett, per J. Burgess.

**North Devon** (4): *Anodonta anatina*, E. shore of Upper Tamar Lake (SS2812), G.A. Holyoak.

**South Somerset** (5): *Limax flavus*, Bridgwater (ST2937), G.A. Holyoak, 2002.

**North Somerset** (6): *Physa acuta* seg., Bath (ST7-6-), J. Llewellyn-Jones, 1997, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**Hampshire** (11): *Lymnaea fuscus*, Crockford Bridge (SZ3598), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**East Sussex** (14): *Lymnaea palustris* seg., Hooe Level (TQ6705), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003); *Lymnaea fuscus*, Manxey Level (TQ6506), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**East Kent** (15): *Lymnaea fuscus*, Stanford (TR1338), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**West Kent** (16): *Lymnaea fuscus*, East Peckham (TQ6849), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**Surrey** (17): *Lymnaea palustris* seg., Wimbledon Common (TQ2372); *Lymnaea fuscus*, Effingham (TQ1155); both det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**North Essex** (19): *Gyraulus laevis*, Pete Tye Common (TM0018), P. Wilson, 2002.

**Suffolk** (25): *Lymnaea fuscus*, Carlton Marshes (TM5099), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**East Norfolk** (27): *Lymnaea palustris* seg., Weavers' Way Drain (TG4319), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**Cambridgeshire** (29): *Sphaerium solidum*, E. bank of R. Great Ouse (TL3974), J. Bass *et al.*, 1999; *Hygromia cinctella*, Harlton (TL3852), M.G. Telfer, 2004.

**Huntingdonshire** (31): *Lymnaea fuscus*, Woodwalton Fen (TL2385), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003) This record is attributed to Cambridgeshire in Carr & Killeen (2003) but it is from vice-county 31.

**Monmouthshire** (35): *Physa gyrina*, Gwent Levels (ST2784), 1999, det. R. Anderson (*J. Conch.* 2003, 38: 7-19, 2003).

**Glamorgan** (41): *Physa acuta* seg., Cardiff (ST1880), Cardiff Pond Survey, 2000, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**Caernarvonshire** (49): *Lymnaea fuscus*, Rhyd-y-clafdy (SH3335), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).



**Flintshire** (51): *Physa acuta* seg., Tyn y Morfa, Talacre (SJ1283), I.D. Wallace, 1997, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**Cheshire** (58): *Physa acuta* seg., Hatchmere (SJ5272), I.D. Wallace, 1997, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**South Lancashire** (59): *Physa acuta* seg., Ewloe sandpit, Upton (SJ4986), S.J. McWilliam, 1996, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**South-west Yorkshire** (63): *Arion owenii*, Little Matlock Wood (SK3189), R. Clinging, 2002, det. R.A.D. Cameron, conf. S. Davies, 2002.

**Durham** (66): *Lymnaea palustris* seg., Joe's Pond (NZ3248), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**North Northumberland** (68): *Monacha cantiana*, Beadnell Bay (NU2327), A.A. Wardhaugh, 2002.

**Cumbria** (69): *Lymnaea fuscus*, Loughrigg Tarn (NY3404), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**Dumfriesshire** (72): *Lymnaea fuscus*, Perchhall Loch Moss (NY1087), det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**Ayresshire** (75): *Physa acuta* seg., Loudun Hill (NS5937), F.B. Woodward, 2000, det. R. Anderson (*J. Conch.* 38: 7-19, 2003).

**Lanarkshire** (77): *Bithynia leachii*, Forth-Clyde Canal, Bishopbriggs (NS6071), A.T. Sumner.

**Midlothian** (83): *Bithynia leachii*, Union Canal, East of Ratho (NT1570), A.T. Sumner; *Vertigo pusilla*, Roslin (NT2763), B. Colville, 2002 conf. J. Chatfield.

**West Lothian** (84): *Bithynia leachii*, Union Canal, Broxburn (NT0771); *Anisus vortex*, Dalmeny (NT1677), both A.T. Sumner.

**Fifeshire** (85): *Lymnaea palustris* seg., Cupar (NO3516), *Lymnaea fuscus*, Newburgh (NO2013); both det. R. Carr and I.J. Killeen (*J. Conch.* 38: 67-71, 2003).

**Dunbartonshire** (99): *Bithynia leachii*, Forth-Clyde Canal, Nr. Knightswood (NS5269), A.T. Sumner.

**South Kerry** (H1): *Arion flagellus*, Kells, W. of Mount Foley (V5684); R. Anderson, 1996.

**North Kerry** (H2): *Geomalacus maculosus*, Connor Pass (Q4805), 1996; *Arion flagellus*, Behy Wood (V6591), 1996; both R. Anderson.

**Mid Cork** (H4): *Arion hortensis*, Inishcarra Woods (W5572), 2000; *Semilimax pyrenaicus*, Ballintemple, Cork City (W7171), 2002; *Lehmannia valentiana*, Blarney Castle and grounds (C8431), 2002; all R. Anderson.

**East Cork** (H5): *Arion flagellus*, Boolypatrick, nr. Blarney (W6075), 2000; *Arion hortensis*, Boolypatrick, Nr. Blarney (W6075), 2000; *Arion owenii*, Boolypatrick, nr. Blarney (W6075), 2000; *Tandonia rustica*, Boolypatrick, nr. Blarney, (W6075), 2000; *Boettgerilla pallens*, Boolypatrick (W6075), 2000; *Lehmannia valentiana*, Fota Wildlife Park, Foaty Island (W7970), 2002; all R. Anderson.

**North Tipperary** (H10): *Arion hortensis*, Solsborough, Nenagh (R8679), R. Anderson, 1996.

**South-east Galway** (H15): *Hydrobia ventrosa*, Mweeloon Lagoons (M3319), R. Anderson, 2001.

**West Galway** (H16): *Lymnaea fuscus*, Lough Mask (M0658); *Myxas glutinosa*, Lough Mask (M0658), both G.A. Holyoak.

**Kildare** (H19): *Lymnaea fuscus*, N. of Castledermot (S7887), G.A. Holyoak, det. D.T. Holyoak; *Arion hortensis*, Newbridge (Pollardstown) Fen (N7715), R. Anderson, 2002.

**Dublin** (H21): *Oxychilus helveticus*, River Dodder at Orwell Road, Dublin (O1529); *Boettgerilla pallens*, Trinity College Grounds (O1633); both R. Anderson, 2002.

**Westmeath** (H23): *Dreissena polymorpha*, Lough Ree (N0446), G.A. Holyoak.

**East Mayo** (H26): *Lymnaea fuscus*, Inishard (M1259); *Myxas glutinosa*, Lough

Mask (M1259); *Planorbarius corneus*, Caher Pier (M1463); *Vertigo geyeri*, Cooley Lough (M1382); *Boettgerilla pallens*, NW. of Claremorris (M3376); all G.A. Holyoak.

**West Mayo** (H27): *Bithynia leachii*, Islandeady Lough (M0887), G.A. Holyoak; *Lymnaea fuscus*, Dooagh Marsh, Dooaghtry (L7468), R. Anderson, 2001, det. R. Carr, 2003; *Myxas glutinosa*, Lough Cullin (G2103); *Planorbis planorbis*, W. bank of River Cloon (M1372); *Planorbarius corneus*, W. bank of River Cloon (M1372); *Acroloxus lacustris*, W. bank of River Cloon (M1372); all G.A. Holyoak; *Arion hortensis*, Clare Island Harbour (L7185); *Arion owenii*, Clare Island (L6986), both R. Anderson, 2002; *Boettgerilla pallens*, Achill Island (F6404), G.A. Holyoak.

**Cavan** (H30): *Lymnaea fuscus*, Lough Gowna (H2889), G.A. Holyoak.

**Fermanagh** (H33): *Lymnaea fuscus*, Lough Scholban (H0061), G.A. Holyoak; *Arion flagellus*, Lough Avehy, Pettico Highlands (H0366), R. Anderson, 1997.

**East Donegal** (H34): *Physa gyrina*, Harvey's Point, Lough Eske (G9684), R. Anderson, 1997 conf. R. Anderson 2003. *Physa acuta* seg. Lough Swilly (C3522), G.A. Holyoak, 2002, det. D.T. Holyoak, conf. R. Anderson, 2003. *Vertigo lilljeborgi*, Lough Inn (C5138); *Arianta arbustorum*, Kinnoge Bay (C6345); both G.A. Holyoak, 2002 conf. J. Chatfield.

**West Donegal** (H35): *Lymnaea fuscus*, E. of Tramore Strand (B9936), G.A. Holyoak, 2002, det. D.T. Holyoak, 2003; *Vertigo angustior*, Kinlackagh Bay (C1844); *Cerņuella virgata*, NW. of Derrybeg (B8025); both G.A. Holyoak, 2002 conf. J. Chatfield.

**Tyrone** (H36): *Physa gyrina*, Washing Bay, L. Neagh (H9066), 1995, reconfirmed R. Anderson, 2003; *Arion lusitanicus*, Crilly House (H6949), 2002; *Arion flagellus*, Laght Hazelwood (H3775), 1999; *Arion hortensis*, Drum Manor Forest Park (H7577); all R. Anderson.

**Armagh** (H37): *Ovatella myosotis*, Victoria Lock, Newry Canal (J1020), 2000; *Leucophytia bidentata*, Victoria Lock, Newry Canal (J1020), 2000; *Physa gyrina*, Oxford Island, Lough Neagh (J0462), 1995, reconfirmed R. Anderson, 2003; *Lymnaea fuscus*, Newry Canal, nr. Cloghoge (J0923), 2000, det. R. Carr, 2003; *Arion flagellus*, St. Patrick's Cathedral, Armagh (H8745), 2002; *Oxychilus draparnaudi*, Cargan's Quarry, Tandragee (J0345), 2002; *Milax gagates*, Mullaghglass Quarry (J2768), 2002; *Boettgerilla pallens*, Drumalane Quarry (J0823), 2000; *Limax cinereoniger*, Annagarrieff NNR (H9061), 2000; *Lehmannia valentiana*, St. Partick's Cathedral, Armagh (H8745), 2000, all R. Anderson.

**Down** (H38): *Hydrobia neglecta*, Ann's Point, Strangford Lough (J5568), 2001; *Hydrobia ventrosa*, Cardew Point Lagoon (J5163), 2001; *Physa acuta* seg., Glastry (J6363), 2000, det. R. Anderson (J. Conch. 38: 7-19, 2003); *Lymnaea fuscus*, M1 Bridge, River Lagoon (J2967), 1999, det. R. Carr, 2003; *Arion flagellus*, Annadale House (J3470), 1999; *Arion hortensis*, Annadale House (J3470), 1999; *Arion owenii*, offices area, Belvoir Forest (J3469), 2000; *Semilimax pyrenaicus*, Hillsborough Forest North (J2458), 2002; *Milax gagates*, Abbey ruins, Grey Abbey (J5867), 2002; *Lehmannia valentiana*, (J3572), Haddington Gardens, Cregagh (J3572), 2000; all R. Anderson.

**Antrim** (H39): *Physa gyrina*, Portglenrue, Lough Neagh (J9703), 1995, reconfirmed R. Anderson, 2003; *Arion flagellus*, The White Rocks, 2 km E. of Portrush (C8840), 1999; *Arion hortensis*, Black Head (J4892), 1999; *Lehmannia valentiana*, Newforge (J3369), 1999; all R. Anderson; *Hygromia cinctella*, Hilden Court, Lisburn (J2765), M. Sykes, per. R. Anderson, 1999.

**Londonderry** (H40): *Physa gyrina*, Ballyronan (H9484), 1995, reconfirmed R. Anderson, 2003; *Arion flagellus*, Bann Estuary at Portstewart (C8036), 1999; *Oxychilus draparnaudi*, Amyan MacFaden's Garden (C8431), 2002; *Tandonia sowerbyi*, Springhill House (H8682); *Lehmannia valentiana*, Amyan MacFadyen's garden at Mountsandel (C8431), 2002; all R. Anderson.

2003 was my first year as non-marine Recorder and I am pleased to report that over 8000 records were received. The high standard of recording was evident from the numerous

new vice-county records. The discovery of *Sphaerium solidum* in the River Great Ouse by Jon Bass, John Blackburn and Caroline Giraudy is particularly noteworthy as this is only the second site for this rare species in Great Britain (*J. Conch.* 38: 61-66, 2003). The discovery by David Long of a second site for living *Lauria sempronii* in Gloucestershire is also very welcome as is his confirmation that it is still present at the site he discovered in the 1980s. There were numerous new records for established alien species including *Boettgerilla pallens*, *Lehmannia valentiana* and *Hygromia cinctella*, including the first record of the last species in Ireland. Roy Anderson's record of *Oxychilus helveticus* from Dublin is also significant as the only record of this alien species in Ireland beyond the original finds recorded by Michael Kerney in Co. Limerick in 1977. Barry Colville continued his work of many years on the rare *Vertigo* species, resulting in new sites for *V. pusilla* and *V. angustior* in Scotland. Special thanks are due to Roy Anderson for his many records from Ireland representing sustained field recording over several years with numerous detailed records of segregate species of the more difficult groups (e.g. *Hydrobia*, *Physa* and *Arion*). Current knowledge of the distribution of these species in Ireland results mainly from his research.

There has been uncertainty for some years regarding the number of species to be recognised among the introduced *Physa* and in the *Lymnaea palustris* group. Recent published revisions of material from Britain and Ireland (Anderson, *J. Conch.* 38: 7-19, 2003; Carr and Killeen, *J. Conch.* 38: 67-71, 2003) are therefore very welcome and the resulting new vice-county records of the segregates are cited above.

Overall, it still seems clear that there remains much to find out regarding the distribution of molluscs in Great Britain and Ireland especially the alien species and recent segregates, but also for at least some of the supposedly well known native species. All the recorders are thanked for sending in their records to the Society.

Geraldine Holyoak



## MARINE RECORDER'S REPORT 2003.

Tom Clifton, who has been working within the remit of the Society's Marine Census, has produced a Sea Area Atlas for S23 (Anglesey) in first draft form. In this he gives distribution information which now includes maps for 47 species which are new to the area. Many of these are shell only records or live records for commonplace species which were ripe for updating, and these results follow naturally from the systematic and detailed recording that is carried out for the purposes of sea area atlases at fine scales such as 2' latitude by 2' longitude. A notable record is for *Sepia orbigniana* which has featured regularly in reports in recent years, as more misidentified specimens in pre-existing collections have been recognised as belonging to this species. This Anglesey record is the northernmost record for what has been considered a southern species hitherto. Some of Tom's work, augmented by records submitted by Shelagh Smith, has resulted in live records for a number of pyramidellid species: *Odostomia angusta*, *O. plicata*, *O. turrita*, *Brachystomia eulimoides*, *Chrysallida indistincta*.

There are also two records for the pyramidellid, *Jordaniella nivosa*. A live specimen, which is a new Sea Area record, has been reported from West Angle Bay, Pembs., S21 (Celia Pain) and a live record from Vellan Drang on the Lizard in Cornwall (S18) represents an upgrading from a shell only category (Julia Nunn).

As part of a survey carried out in the Eastern Irish Sea on the effects on the benthos of certain types of fishing gear (EU RESPONSE project) Ivor Rees has reported live specimens of the tellinacean *Solecurtus scopula*. This sublittoral species inhabits gravels but there are sparse records for it.

Coincidentally, two members, Shelagh Smith and Bill Pocock, found shells of *Truncatella subcylindrica* after sorting samples from their respective field trips to St Aubins Bay on Jersey. Although shells have previously been reported from Guernsey these are the first records of the species from Jersey. Both recorders are curious as to where the species is living at this site, as the locality does not appear to offer suitable habitat.

Julia Nunn reports that *Osilinus (Monodonta) lineatus* has extended its northern range limit on the east coast of Ireland by more than 17km. She found the species in 2003 at Benderg Bay; seen here for the first time since 1901. The species has also been found even further north, for the first time in Strangford Lough Narrows and in the main lough, but not (as yet) on the Outer Ards Peninsula. Settlement appears to have commenced in the mid to late 1990's, with those in the main lough settling in 2000. The number of specimens found is low, with densities not exceeding 1/m<sup>2</sup> in Strangford Lough.

In his Master's thesis on the Nudibranchs of Helgoland in the North Sea (Sea Area 51) Philipp Schubert has recorded a list of 34 species of which fifteen species are new to the Sea Area: *Aplysia punctata*, *Coryphella gracilis*, *Cuthona caerulea*, *Cuthona pustulata*, *C. rubescens*, *Geitodoris planata*, *Elysia viridis*, *Eubbranchus farrani*, *E. tricolor*, *Facelina bostoniensis*, *F. coronata*, *Goniodoris nodosa*, *Limapontia senestra*, *Onchidoris pusilla* and *Tritonia hombergii*. There are doubtless many other similar honeypots of information in the public domain which may not readily come to my attention. Now that the transfer of Society data, currently in Recordit format, to Recorder 2002 is well under way, an objective in future marine recording efforts will be to seek out literature and electronic records which are contained in project and survey reports, student theses etc. and I ask members of this Society to help in this endeavour.

I thank those who have submitted data for inclusion in this report and urge members of the Society who would like guidance on recording techniques, or who would like to become involved in marine recording, to contact me.

Jan Light, April 2004

**REPORT OF THE HON. CONSERVATION OFFICER 2003 – 2004**

Selected key items from the 2003 - 04 year are summarised below.

**Advice and help**

Has been given to many individuals and organisations and some examples include:

- The Gloucestershire Wildlife Trust was given advice regarding habitat management for *Helix pomatia* on one of their reserves.
- The Sussex Wildlife Trust was given advice on management plan proposals for areas of the Pevensey Levels supporting a number of BAP Priority Species.
- Arun District Council was given information on sites of the molluscan importance in the Arun valley.
- Specimen identification confirmations were undertaken for several members and organisations (e.g. the Environment Agency, Winchester);
- The RSPB were provided with views concerning the molluscan conservation value of certain areas of North Kent marsh lands in the Cliffe area.
- Scottish Natural Heritage was given assistance with specimens sent from Lochs on Orkney Isles.

**British Wildlife**

The production of a molluscan wildlife report for this journal has continued with an increase from two to three reports annually. The Conservation Officer has used this column to publicise selected aspects of work undertaken by the Society.

**Invertebrate Link (formerly J.C.C.B.I.) and The Invertebrate Conservation Trust (Buglife)**

Membership of the Committee continues providing valuable contacts with other organisations. The Conservation Officer has attended all meetings. Member organisations of Invertebrate Link present annual summaries of their organisation's conservation work throughout the year and the Conservation Officer tabled a short summary of the Society's work at the October 2003 meeting. The ICT has provided a variety of conservation news items, reports and initiatives from the wider conservation world, that have been circulated to various council members.

**The Fourth Quinquennial Review of Schedules 5 and 8 of the Wildlife and Countryside Act, 1981**

In late 2002 it became known that the Joint Nature Conservation Committee (JNCC) had recommended *Helix pomatia* for addition to Schedule 5 of The Act. On behalf of the Conchological Society, the Conservation Officer, assisted by other Society members, is embarking upon an initiative to try to gather more information on the snail in 2004/05 particularly in its three core areas, the Cotswold and Chiltern Hills and the North Downs.

**Mollusc World**

The Conservation Officer has contributed articles to all editions of the publication. Issue 2 was able to report upon a selection of conservation news items including summaries of two of the UK molluscan BAP steering group meetings, those dealing with terrestrial and freshwater Priority Species. Issue 3 presented a thorough review of all current UK molluscan conservation statuses.

**Biodiversity Matters**

- A meeting of the UK BAP Terrestrial Steering Group (dealing with the BAP priority

species *Vertigo geyeri*, *V. genesii*, *V. angustior*, *V. moulinsiana* and *Catinella arenaria*) took place at Coleraine, Northern Ireland in June 2003. Five Society members attended the meeting which was reported in *Mollusc World* 2: 11. No meeting of the Freshwater UK BAP Steering Group has taken place in the last year.

· Several Society members have been involved on a professional basis with survey and monitoring work on Biodiversity Steering Group Priority Species including *Margaritifera margaritifera*, *Vertigo moulinsiana*, *V. angustior*, *V. geyeri*, *V. genesii*, *Myxas glutinosa*, and *Pisidium tenuilineatum*. Work has also involved RDB species such as *Valvata macrostoma*.

Several Society members have been involved on a professional basis with survey and monitoring work on Biodiversity Steering Group Priority Species including *Margaritifera margaritifera*, *Vertigo moulinsiana*, *V. angustior*, *V. geyeri*, *V. genesii*, *Myxas glutinosa*, and *Pisidium tenuilineatum*. Work has also involved RDB species such as *Valvata macrostoma*.

### **Associations with other organisations**

A field meeting in June 2003 Society members and guests visited the Hampshire Wildlife Trust's Winnall Moors reserve on the River Itchen in Winchester to examine the habitat of the rare BAP Priority species *Pisidium tenuilineatum*.

The Conservation Officer continues to attend conservation committee meetings of The Sussex Wildlife Trust. He wrote an article on alien non-marine molluscs and for the 'Adastra' magazine published annually by the Biological Records Centre and presented at the annual Biological Recorders Seminar of the Trust. The article was able to draw attention to the work of the Conchological Society.

The Conchological Society and many of its members have been closely associated with numerous aspects of English Nature's work since its formation, arising from the restructuring of the former Nature Conservancy Council. Following study of Lord Haskins' report detailing possible changes to the workings and structure of English Nature the Society sent a letter from the President and Conservation Officer to DEFRA. The Society sought reassurance from Government that any changes to the organisation would not lead to its loss of independence. A reply from Ben Bradshaw, Minister for Nature Conservation and Fisheries clarified details explaining that the new body would be established as an executive Non-Departmental Public Body. A brief note on this item will appear in *Mollusc World*.

M.J. Willing  
Hon. Conservation Officer



### **HON. MEMBERSHIP SECRETARY'S REPORT FOR 2003**

Membership of the Society at the end of 2003 was 334. This includes Life Members, Honorary Members, Ordinary Members, Family Members and Institutions. There were 17 new members in the year, but 15 members have resigned or lapsed through non-payment of subscription, giving a net increase of 2 members for the year.

During the year there were 80 Subscribers to the *Journal of Conchology* .

M. Weideli

### **HEALTH AND SAFETY REPORT FOR THE YEAR 2003**

Early in the year it was brought to the attention of Council that the Society should have a Health and Safety Policy. A document was drafted by Pryce Buckle and following due consideration approved by Council.

The first field meeting to take place under the new policy was that led by William Penrice to Arran in May 2003. I hold copies of H&S documentation for the following field meetings: Arran, Knightwick, Dawlish, Budleigh Salterton, Ightham and Winnall Moors. The field meeting to Old Sulehay led by Brian Eversham was covered by his own Wildlife Trust's insurance. I am pleased to say that there are no incidents to report.

Jan Light  
President









## INSTRUCTIONS TO AUTHORS

Manuscripts should be sent to:

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**PAPERS** Two copies of text and illustrations should be submitted; one set of illustrations must be good quality originals. Authors should refer to *New Instructions to Authors* in 37 part 1. Authors are reminded of the high cost of printing and therefore are expected to write concisely and to make maximum use of page size when designing artwork and tables.

**COMMUNICATIONS** These are intended to be short notes of an original nature which do not merit the treatment of a full paper. *Communications* do not normally contain any figures, tables or plates and should conform in style to that of recent issues of the *Journal*.



# Journal of Conchology

Vol. 38, Part 4, December 2004

## Contents

### PAPERS

	PAGE
ABSALÃO R.S. & SANTOS F.N. Recent deep-sea species of <i>Benthonellania</i> Lozouet, 1990 (Gastropoda: Rissooidea) from the south-western Atlantic, with descriptions of two new species utilizing a shell morphometric-multivariate approach.	329
ANDERSON R. <i>Arion occultus</i> n.sp., a new slug of subgenus <i>Kobeltia</i> Seibert (Pulmonata: Arionidae) from Ireland.	341
BOYER F. Description of a new <i>Cystiscus</i> (Gastropoda: Cystiscidae) from the Mascarene Islands.	355
BRIERS R.A. The relationship between abundance and prevalence of trematode parasites infecting <i>Lymnaea stagnalis</i> L.	363
HAUSDORF B. & GUEVARA MUNOZ S. <i>Adelopoma peruvianum</i> new species from northern Peru (Gastropoda: Diplommatinidae).	369
HORSÁK M. & NEUMANOVÁ K. Distribution of <i>Pisidium globulare</i> Clessin, 1873 (Mollusca: Bivalvia) in the Czech Republic and Slovakia with notes to its ecology and morphological characters.	373
TRIA NTIS K.A., MYLONAS M. & VARDINOYANNIS K. Contribution to the knowledge of the terrestrial malacofauna of the island group of Dionysades (Crete, Greece).	383
TRIA NTIS K.A., POKRYSZKO B.M., VARDINOYANNIS K & MYLONAS M. A new species of <i>Truncatellina</i> (Gastropoda: Vertiginidae) from Mount Ossa (=Kissavos) (Greece).	393
WU M. Two new <i>Angiomphalia</i> species from China (Pulmonata: Helicoidea) extending the eastern fringe of the Hygromiidae.	399
VON PROSCHWITZ T. On the distribution and ecology of <i>Vertigo substriata</i> (Jeffreys), <i>Vertigo modesta arctica</i> (Wallenberg), <i>Vertigo lilljeborgi</i> (Westerland) and <i>Vertigo alpestris</i> Alder in France and on the Iberian Peninsula.	411
MILLAR A.J. & WAITE S. Patterns of shell damage among snails from a coppice woodland in Sussex, England.	421
KILLEEN I.J. & MCFARLAND B. The distribution and ecology of <i>Gyraulus acronicus</i> (Férussac, 1807) (Gastropoda: Planorbidae) in England.	441

### COMMUNICATIONS

GIUSTI F. & SCHEMBRI P.J. The date of publication of the Non-marine molluscs of the Maltese Islands.	457
HOLYOAK D.T. & HOLYOAK G.A. <i>Catinella arenaria</i> (Succineidae) living in Brittany, NW France.	458
HOLYOAK G.A. <i>Myxas glutinosa</i> (Gastropoda: Lymnaeidae) in Irish lakes.	459
POCOCK B. <i>Truncatella subcylindrica</i> - a new shell record for the Channel Islands.	461
CUCHERAT X. <i>Vertigo moulinsiana</i> in the Upper Valley of the Somme River (Northern France).	462
CUCHERAT X. <i>Leiostyla anglica</i> (Wood, 1828) living in Northern France.	463
BOOK REVIEW	464
OBITUARY	466
PROCEEDINGS	474

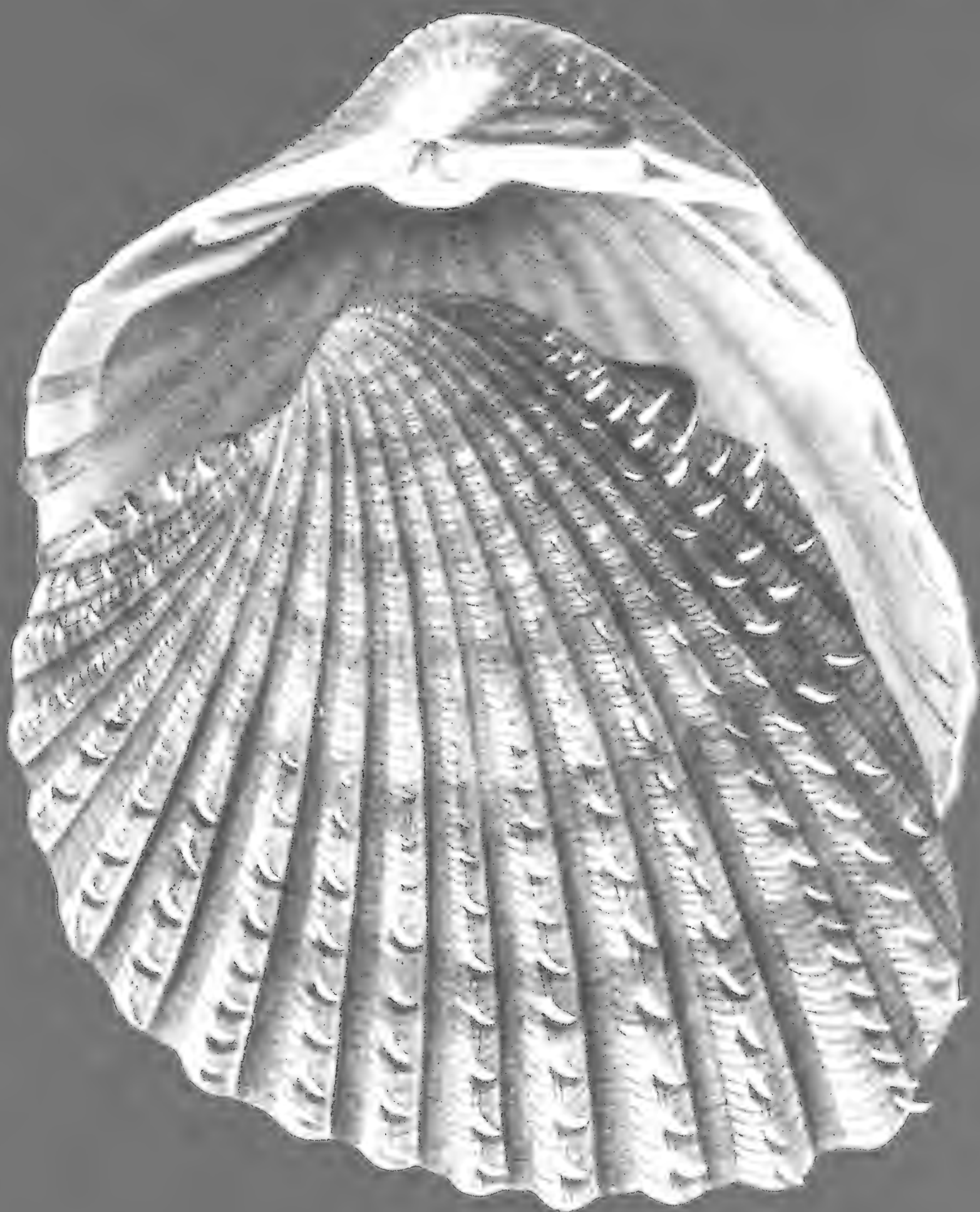


ISSN 0022-0019

Journal of  
Conchology

(Established 1874)

Vol.38, Part 5, May 2005



*promoting* Conservation,  
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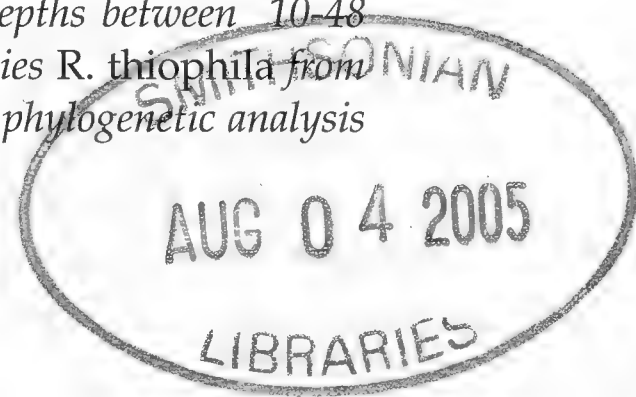
Printed by Henry Ling, The Dorset Press, Dorchester DT1 1HD

# ANOTHER BIVALVE WITH DREADLOCKS: LIVING RASTA LAMYI FROM AQABA, RED SEA (BIVALVIA: LUCINIDAE)

JOHN D. TAYLOR<sup>1</sup>, EMILY A. GLOVER<sup>1</sup>, MARTIN ZUSCHIN<sup>2</sup>, PETER C. DWORSCHAK<sup>3</sup> & WOLFGANG WAITZBAUER<sup>4</sup>

**Abstract** Live-collected specimens of the lucinid bivalve, *Rasta lamyi*, hitherto known only from dead shells, possess long periostracal pipes arranged radially around the valve margins. The bivalves were found in the northern Red Sea, mostly in muddy sand, with sparse seagrass cover, at depths between 10–48 m. The periostracal pipes and general anatomy are similar to those of the type species *R. thiophila* from Western Australia. Although the morphological features are unusual, a molecular phylogenetic analysis demonstrates that *R. lamyi* groups within a major clade of shallow water lucinids.

**Key words** Lucinidae, periostracal pipes, *Rasta lamyi*



## INTRODUCTION

The biology of lucinid bivalves has attracted much attention because of the probable obligate symbiosis with sulphide-oxidising chemautotrophic bacteria housed in the gills from which they derive a considerable part of their nutrition (Reid & Brand, 1986; Reid, 1990; Distel, 1998). Many novel features of their anatomy and habitat distribution are associated with the symbiosis (Taylor & Glover, 2000a). One of the most unusual lucinids is *Rasta thiophila* Taylor & Glover, 1997 (see also Taylor & Glover, 2000b for nomenclature), described from around the Houtman Abrolhos Islands, off Western Australia. This species is remarkable for the long pipes that extend radially from the margin. These pipes are formed from fused periostracum and most are thought to act as conduits for the passage of interstitial water, with dissolved sulphide from the sediment, into the mantle cavity where it is utilised by sulphide-oxidising bacteria housed in the ctenidia (Taylor & Glover, 1997). A shorter, anterior dorsal pipe, sometimes stained with iron oxide, likely provides a conduit for oxygenated water.

Subsequent to the discovery of *R. thiophila*, we recognised (Glover & Taylor, 1997; Taylor & Glover, 2000b) a second species, *Rasta lamyi* (Abrard, 1930), that is uncommon, but distributed from the northern Red Sea to northeastern Madagascar (see also Mienis 2000). This species was known only from dead shells, but traces of possible dried periostracal pipes were seen on a single specimen (Glover & Taylor, 1997 fig. 3a), suggesting similar habits to the Australian species. Recent research activity in the northern Red Sea by the University of Vienna and Natural History Museum, Vienna discovered a few live individuals of *Rasta lamyi* and these were fixed for morphological study and molecular analysis. In this paper we describe the major features of *R. lamyi*, compare these with *R. thiophila* and discuss the phylogenetic position of the genus, based on morphological and molecular characters.

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## RESULTS

### HABITAT OF *RASTA LAMYI*

Information on the habitat of *Rasta lamyi* derives from detailed studies of shallow water communities and sediment associations made by the University of Vienna in the northern Red Sea. Details of the location, methods, sediment types and fauna for the Safaga localities are given in Zuschin & Oliver (2003). *Rasta lamyi* was found in quantitative bulk samples and qualitative surface collections (Safaga, Egypt), in quantitative quadrat samples along transects (Aqaba, Jordan), and in association with burrow systems of a callianassid shrimp (Aqaba). A feature of these sampling activities is the low abundance and frequency of both living and dead shells of this bivalve. In Safaga, a single, dead whole shell was found in 85 qualitative samples from soft substrata and 113 valves (plus a single living specimen) were found in only three of 13 quantitative bulk samples (each with a volume of 29 cm<sup>3</sup>), where they contributed between 0.01% and 1.13% of the total bivalve abundance. Their contribution to the overall bivalve abundance from bulk samples in Safaga is only 0.05% (Zuschin & Oliver, 2003). Similarly, in Aqaba, 408 quadrats (60 cm x 60 cm), covering the uppermost 10 to 20 cm of the sediment, revealed only 11 living specimens and 14 empty valves.

Distinct habitat preferences for *Rasta lamyi* are evident from our sampling programme. Most shells (6 living, 121 empty valves) were found in muddy sand with sparse coverage of seagrass or in muddy sand at the margin of such a seagrass meadow (*Halophila stipulacea* in Safaga, *Halophila* sp. in Aqaba). Additionally, four live specimens and 6 valves were located in muddy sand without seagrass at Aqaba, and three shells (a juvenile live specimen and a single empty valve in Safaga, an adult live animal in Aqaba) were also found in coral sand. Neither living specimens, nor empty valves were found in mud, reef slope sands, coral sand with seagrass and in the mangrove channel. Also muddy sands with a dense coverage of seagrass were apparently not inhabited by *Rasta lamyi*. For muddy sand and muddy sand with seagrass habitats, the water depths for *R. lamyi* ranged from 9.6-20 m at Aqaba and from 40-48 m at Safaga. For *Rasta lamyi* from coral sand, water depths were 10 m at Safaga and 25 m at Aqaba.

For most live collected specimens from Aqaba detailed life habit information is available. Eight specimens were burrowed 10 cm into the sediment lying close to the anoxic boundary layer and three specimens were found only few centimetres below the sediment surface. Two living specimens, from 9.6 and 18 m water depths in muddy sand at the margin of a seagrass meadow, were found burrowed 15-20 cm deep in the compact sediment, about 5 cm away from the funnel of *Glypturus laurae* (de Saint Laurent, 1984 in de Vaugelas & de Saint Laurent, 1984), a callianassid shrimp (for a description of the burrows see de Vaugelas (1984). The life positions of the specimens found associated with the shrimp burrow system, and of four other specimens from muddy sand and muddy sand with seagrass, were not oriented vertically with the dorsal margin uppermost. Instead the shells were inclined, with the commissural plane lying in a horizontal position.

### MORPHOLOGY

#### External appearance

Apart from the umbonal regions, the exterior surface of the shell is obscured by dense, shaggy, periostracal growths, comprising the current periostracal pipes at the shell margin and the imbricating remnants of the succession of pipes left from previous growth stages (Fig. 1). Between 10–14 pipes extend from the shell margin. Some of these are only short extensions, but the largest measured up to 74 mm. Most of the pipes measured between 1.5-2.4 mm in diameter, but the anterior pipes were around 3.3 mm wide. The pipes are increasingly thin and diaphanous at their distal ends. Posterior

pipes, sometimes slightly broader than the ventral pipes, lie adjacent to the posterior exhalant aperture of the bivalve. A feature of all the animals is the orange-stained, anterior periostracal pipe. In one specimen (Fig. 1A) this reaches a length of at least 58 mm. The anterior pipes are more robust and stiffer than those on the ventral margin and are formed from many overlapping layers of periostracum (Fig. 4). Elemental analysis showed that the orange coloured deposits on the pipe layers are high in iron and this is likely amorphous iron oxide (no pattern from x-ray diffraction). The anterior pipe occurs in the same position as the anterior oxygenating sediment tube found in other lucinids, but in contrast to *Rasta* spp, these are typically mucous-lined tunnels through the sediment to the surface, formed by the actions of the foot (Allen, 1958; Stanley, 1970). Additionally, many lucinids have orange/brown iron staining on the shell close to the position of the anterior tunnel.

### Internal

The anterior adductor muscle is elongate (Figs 2, 3), thin, and diverges widely from pallial line producing a wide gutter between the face of the muscle and the anterior mantle margin. No structures comparable to the mantle gills of some lucinids (Taylor & Glover, 2000a) are present. The posterior adductor muscle is short and oval. The foot is vermiform, narrow, cylindrical, without a heel, and with a relatively long glandular, ciliated tip (Fig. 4). The ctenidia are relatively small, occupying about 1/2 mantle cavity and comprising inner demibranchs only. Ctenidial filaments are thick, with a broad abfrontal zone of bacteriocytes containing abundant coccoid bacteria about 3-4 µm long and 1.5-2.5 µm wide (Fig. 5). Poor fixation precluded further detailed study. The labial palps are very small, consisting of slight swellings at the margin of the thin lips. The posterior apertures are simple with no mantle papillae; the exhalant aperture is a small narrow slit while, unusually for Lucinidae, the inhalant aperture is not closed ventrally from the pedal gape by mantle fusion.

### Comparison with *Rasta thiophila*

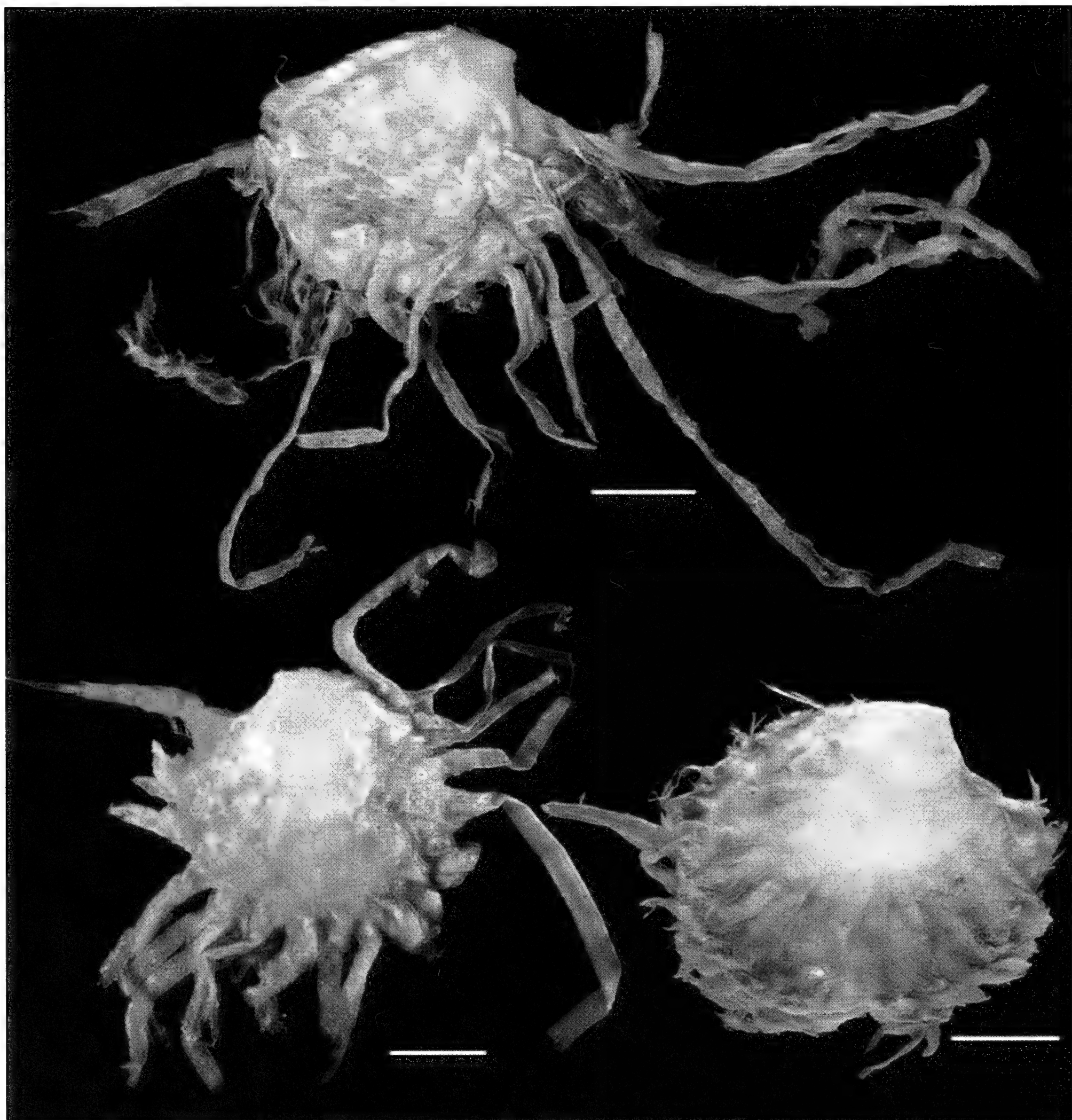
In general, the living *Rasta lamyi* is similar to *R. thiophila* from Western Australia. In *R. lamyi* the pipes are both narrower in diameter and less robustly constructed. Both species have a shorter, anterior, iron oxide-stained pipe (not explicitly mentioned in the original description of *R. thiophila*).

The general anatomy of *R. lamyi* is similar to that of *R. thiophila* (details in Taylor & Glover, 1997), but the ctenidia are relatively smaller and the foot thinner with a longer glandular tip. The two species differ in the form of the posterior apertures: *R. thiophila* has a very short length of ventral mantle fusion forming an inhalant aperture, while in *R. lamyi* there is no fusion demarcating the inhalant area. The lack of a fused inhalant aperture is an unusual feature in Lucinidae and has previously been recorded only in *Parvilucina tenuisculpta* (Reid & Brand, 1986).

## PHYLOGENETIC POSITION

Molecular analysis of *Rasta lamyi* using sequences from 18S and 28S rRNA genes in combination with a range of other Lucinidae species was reported by Williams, Taylor & Glover (2004). The results of this analysis (Fig. 5) showed that the lucinids sequenced so far form six major groups and that *R. lamyi* falls within a major clade of lucinids that also contains, amongst others, species of *Lucina*, *Cardiolucina*, *Divaricella*, *Loripes* and *Wallucina*, but groupings within this clade are not well supported. Continuing analysis with a wider range of lucinid species and using sequences from additional genes may resolve the position of *R. lamyi* more robustly. Despite the unusual morphological

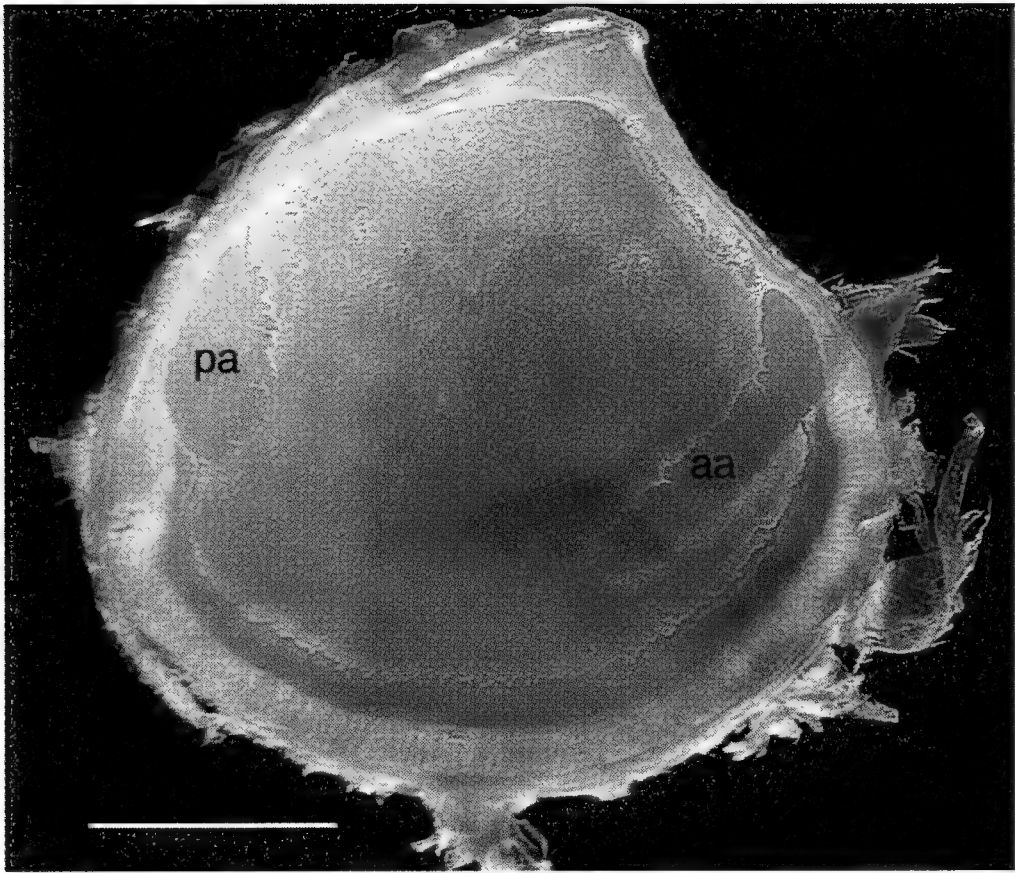




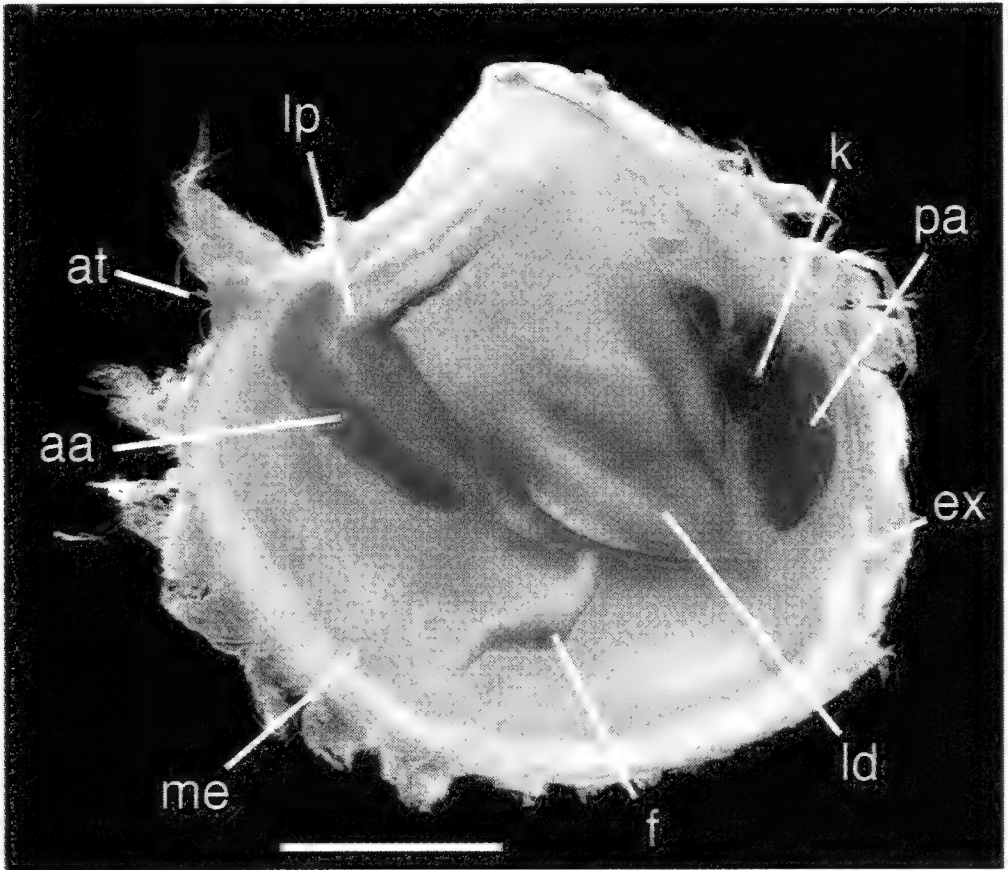
**Figure 1** *Rasta lamyi* (Abrard, 1942) three individuals from Aqaba showing external features. Note the red stained anterior pipe in B. Scale bars = 10 mm

features, *R. lamyi* groups with an array of lucinids with more “standard” characters. Using evidence from shell characters, we thought (Taylor & Glover, 1997; Glover & Taylor, 1997) that the *Rasta* species most closely resembled species of *Megaxinus*, a genus with known species from the eastern Atlantic, Mediterranean and northern Indian Ocean (with further unpublished records from Indonesia and northern Australia - R. von Cosel personal communication and our own data). Unfortunately, no species of *Megaxinus* has so far been available for molecular analysis. However, we note that the Recent Mediterranean species, *Megaxinus unguiculinus* Pallary, 1904, seems to lack periostracal pipes (unpublished observations by J.T & E.G. on a single juvenile specimen).

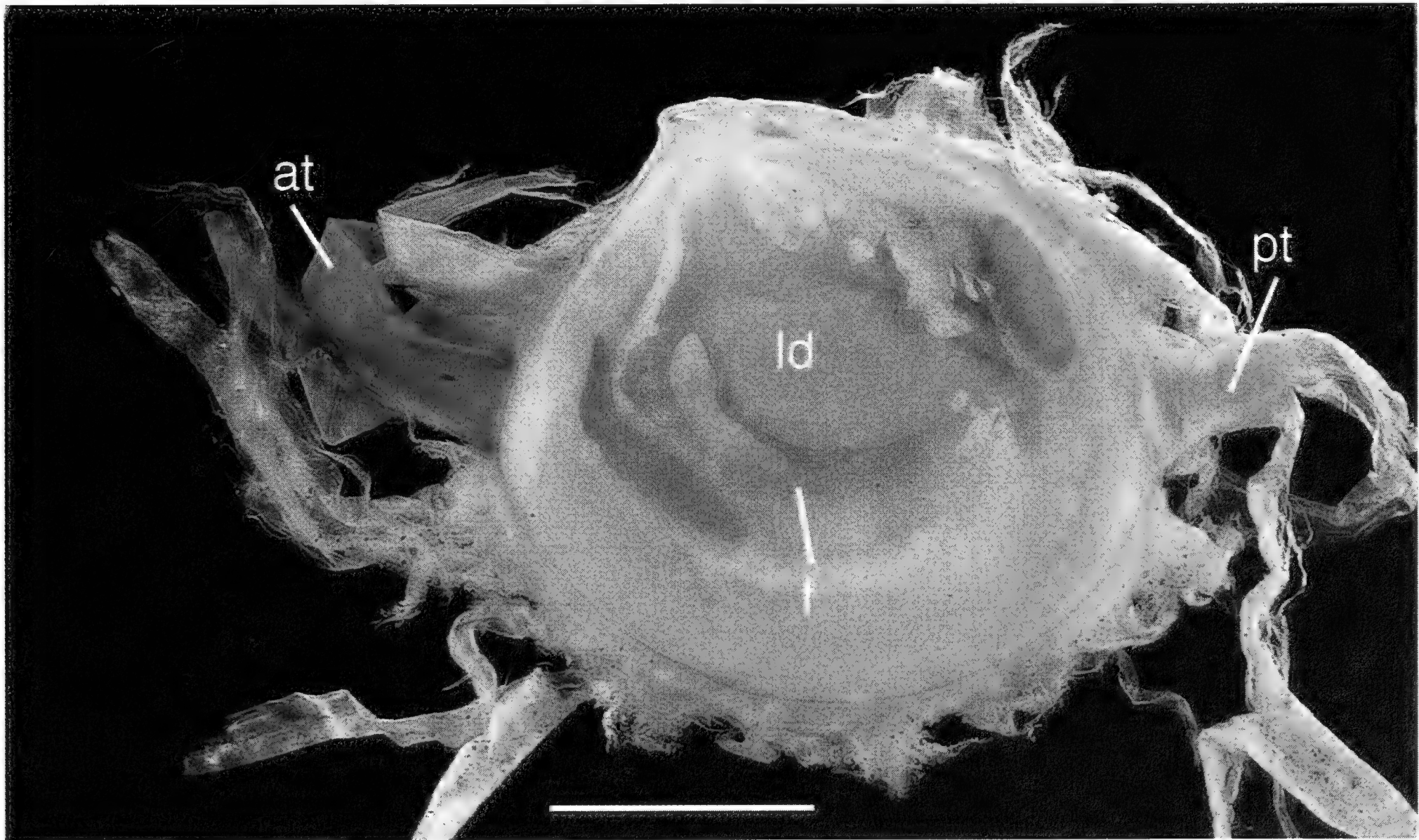




**Figure 2** *Rasta lamyi* interior of left valve. aa - anterior adductor scar; pa - posterior adductor scar. Scale bar = 10 mm.

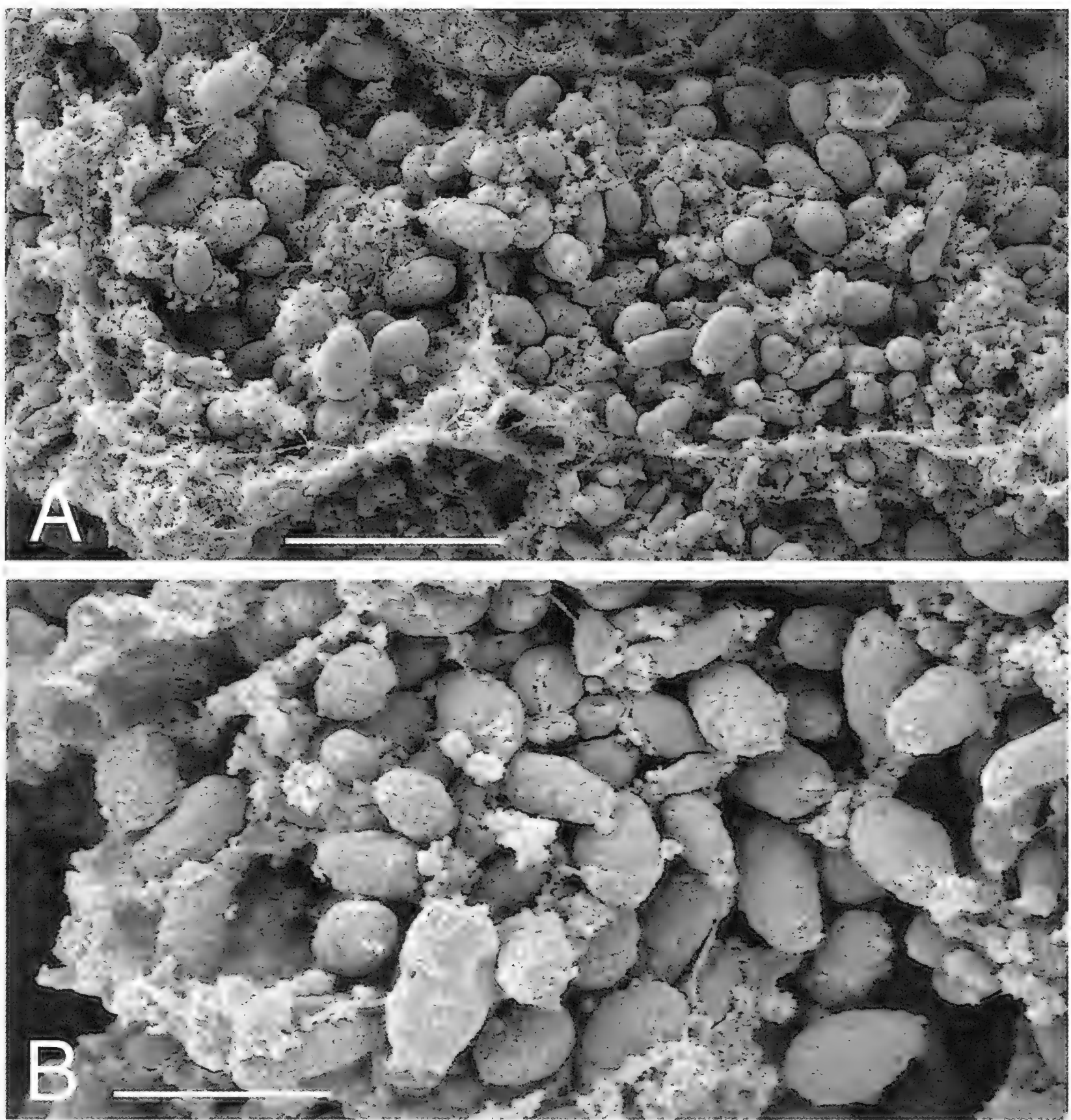


**Figure 3** General anatomy of *R. lamyi* with left valve and mantle removed. aa – anterior adductor muscle, at - anterior tube, ex - exhalant aperture, f – foot, k – kidney, ld - left demibranch of ctenida, lp – labial palps, me - mantle edge, pa – posterior adductor muscle. Scale bar = 10 mm.



**Figure 4** *R. lamyi* showing prominent red stained anterior tube. Left valve and mantle removed. at – anterior tube, f – foot, ld – left demibranch, pt - posterior tube. Scale bar = 10 mm.



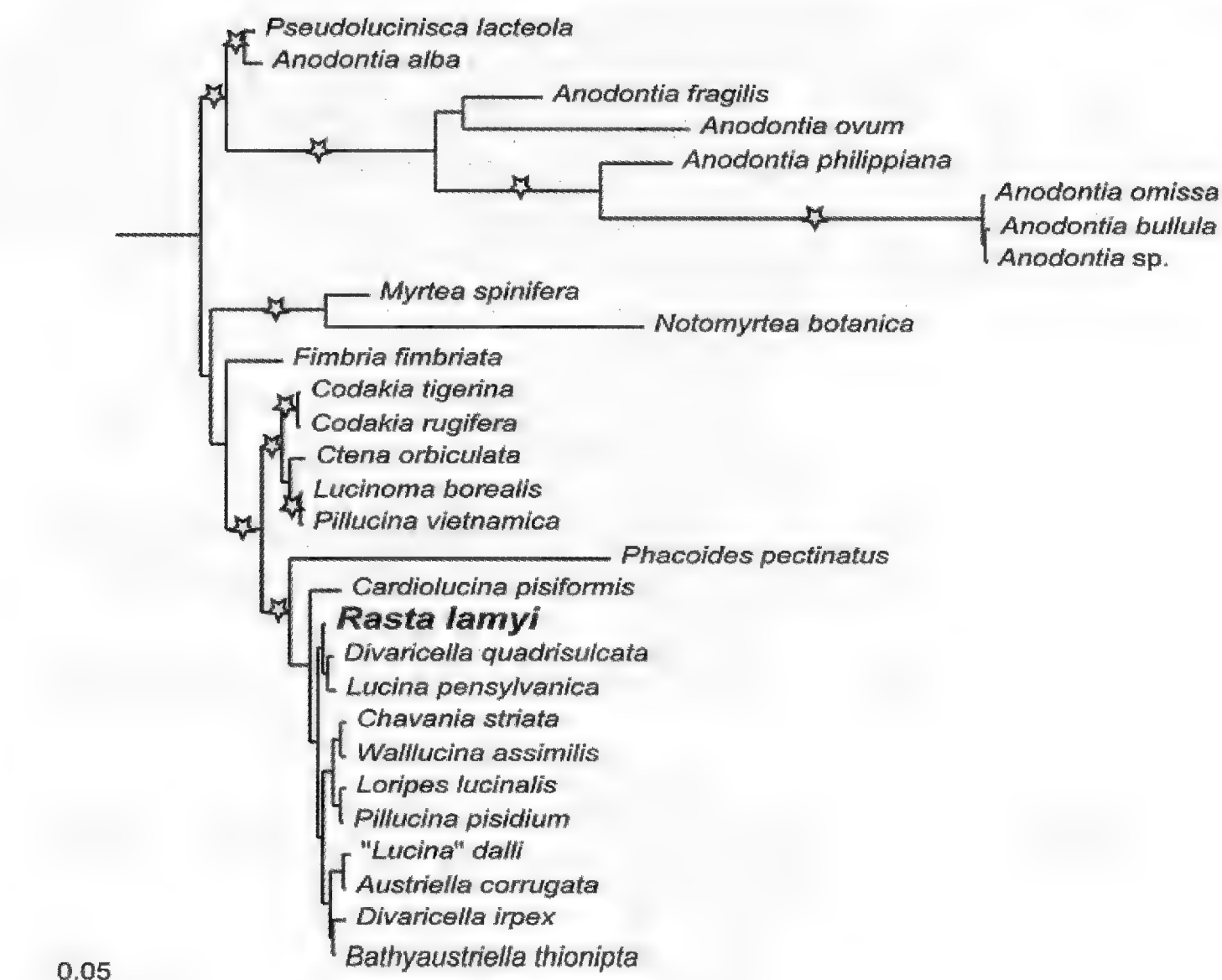


**Figure 5** Coccoid bacteria within bacteriocytes of ctenidial filament of *R. lamyi*. SEM of critical-point dried, glutaraldehyde-fixed, gill tissue. A. scale bar = 10 µm. B. scale bar = 5 µm.

## DISCUSSION

For *Rasta thiophila* from Australia, thin sections showed that the walls of the pipes were multilayered and the constructional material continuous with the periostracum of the shell. Also, the ribbons of periostracum on opposing valves became fused into a tube about 3–4 mm from the valve margins. It was postulated (Taylor & Glover, 1997) that the periostracum was secreted at the mantle margins in a semi-fluid state and pushed into the long pipes by the activities of the highly extensible and rotatory, vermiform foot, with perhaps modification from the glandular tip of the foot. The form of the pipes in *Rasta lamyi* is very similar and the construction process is likely the same. Much sediment is incorporated into outer wall of the pipes suggesting they were initially sticky.

Sulphide mining has been documented in a few species of lucinids whereby a system of narrow tunnels is constructed by the highly extensible foot ventral to the vertically positioned bivalve (Stanley, 1970; Turner, 1985; Cary, Fry, Felbeck & Vetter, 1989; Taylor & Glover, 2000) and probably most lucinids construct such tunnels. Similar, but more elaborate tunnels are made by some species of the unrelated family Thyasiridae (Oliver & Killeen 2002; Dufour & Felbeck, 2003). The periostracal pipes of *Rasta lamyi* and *R. thiophila* are interpreted as a method of forming more permanently lined ventral tubes for the passage of interstitial water. The anterior, red stained pipe of *R. lamyi* is located in the position of the usual lucinid anterior mucous-lined sediment tunnel that brings in



**Figure 6** Molecular phylogeny of species of Lucinidae produced by Bayesian analysis of concatenated gene sequence data from 18S rRNA and 28S rRNA genes. Position of *Rasta lamyi* highlighted in bold. Stars indicate branches with greater than 90% posterior probabilities. Full details of methods and taxa in Williams *et al.* 2004.

oxygenating water to the bivalve and similarly, functions as a more permanent conduit. An additional function of the anterior tunnel in lucinids was proposed by Dando *et al* (1985, 1986, 1994), who observed that *Lucinoma borealis* and *Myrtea spinifera* construct new inhalant tunnels, also orange stained, at frequent intervals and that a cone of oxidised sediment develops above the anterior end of the bivalve. They postulated that insoluble sulphides in the sediment are oxidised by the inhalant current and dissolved sulphide diffuses into the inhalant tube from where it is transported to the sulphide-oxidising bacteria in the gills. This mechanism is unlikely in *R. lamyi* where the anterior periostracal pipe is a more permanent arrangement and frequent changes in position are unlikely. In any case, the dissolved sulphide would be likely oxidised in the oxygenated water before reaching the symbionts. Furthermore, in many lucinids the anterior mantle surface adjacent to the adductor muscle has become the main site of respiration, with the ctenidia housing the sulphide-oxidising bacteria (Taylor & Glover, 2000).

Clearly, the pipes of both *Rasta* species are multifunctional. The anterior pipes form a tube for the oxygenating water flow from the sediment surface; the ventral pipes are likely involved in drawing sulphide-containing interstitial water from the sediment into the mantle cavity, while the posterior-most pipes are linked to the posterior exhalant aperture and are concerned with directing water flow out of the mantle cavity.

In life, most lucinids are oriented vertically in the sediment with the umbones uppermost and the observation for *R. lamyi* that at least some of the live individuals were found in a horizontal position and also in apparent association with callianassid burrow systems is interesting. It is possible that the bivalves were oriented in relation to the gradients in the oxidised/suboxic sediment around the callianassid shrimp tunnels rather than to the sediment surface.

Now that the habitat of *Rasta lamyi* has been located it would be of great interest to study more of the biology of this very unusual bivalve.



## ACKNOWLEDGEMENTS

We are grateful to Suzanne Williams (Zoology, NHM) for the molecular sequences and to Ben Williamson and Gordon Cressey (Mineralogy, NHM) for help with the analysis of the iron staining on the pipes. Fieldwork of MZ in Aqaba was supported by the Hochschuljubiläumsstiftung der Stadt Wien.

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# THE WEST AFRICAN SPECIES OF THE GROUP *NASSARIUS DENTICULATUS* (MOLLUSCA, NEOGASTROPODA), WITH THE DESCRIPTION OF A NEW SPECIES

E. ROLÁN<sup>1</sup> & J.M. HERNÁNDEZ<sup>2</sup>

*Abstract* The type material of the species morphologically similar to *Nassarius denticulatus* referred from the West African coast is studied. The bibliographic records and the geographic distribution of all them are shown. The taxa *N. denticulatus*, *N. turbineus*, *N. webbei*, *N. desmoulioides*, and *N. clathratus* are studied, reaching the conclusion that the shells from West Africa, usually considered in the taxon *N. desmoulioides*, are clearly different from the lectotype of this species. Therefore it is an unnamed species which is described in the present work. A neotype for *N. turbineus* is designated.

*Keywords* Gastropoda, Prosobranchia, Nassariidae, *Nassarius desmoulioides*, West Africa, East Africa, taxonomy, new species

## INTRODUCTION

The genus *Nassarius* Duméril, 1806 from the West African coast has been thoroughly studied by Adam (1976) and Adam & Knudsen (1984). Most of the species for this area were described and represented. A lot of information on species of Nassariidae is dispersed in many works. The Indo-Pacific fauna was widely studied by Cernohorsky (1984).

There seems to be general agreement about the morphology of most of the species with a similar shell to *N. denticulatus* but some problems require a different interpretation. The two most common species of this group are apparently well known: *N. denticulatus*, with axial ribs and spiral cords, without nodules at their intersection, and with a brown subsutural spiral band (rarely with white blotches), and *N. desmoulioides*, being similar but bearing nodules at the intersection of ribs and cords, mainly in the subsutural region, and having a more irregular color, most frequently presenting as axial bands which are more evident subsuturally.

In Adam & Knudsen (1984) a discrepancy appears, because the fig. 7 of the plate 1 (a paratype of *N. desmoulioides*, from South Africa) is more similar to shells of *N. denticulatus* than to the shells represented in plate 1, fig. 8 and text-fig. 11, which are more in conformity with the morphology of the West African shells of the species, usually considered in this taxon by collectors and dealers.

Morán *et al* (1989) discussed the validity of both taxa (*N. denticulatus* and *N. desmoulioides*), in their opinion, due the similarity of both lectotypes (see below in the discussion).

In order to clarify this situation, the authors present some information on this group of species, which are the subject of the present work.

## ABBREVIATIONS:

AMNH American Museum of Natural History, New York

BMNH The Natural History Museum, London

DBUA collection of Departamento de Biología, Universidad Autónoma, Madrid

<sup>1</sup> Museo de Historia Natural, Campus Universitario Sur, 15782 Santiago de Compostela, Spain. e-mail: emiliorolan@inicia.es

<sup>2</sup> Capitán Quesada, 41, 35460 Gáldar, Gran Canaria, Spain. e-mail: jmho@infonegocio.com

MNCN Museo Nacional de Ciencias Naturales, Madrid

MNHN Muséum Nationale d'Histoire Naturelle, Paris

MNHST Museo de la Naturaleza y el Hombre, Santa Cruz de Tenerife

ZMUC Zoologisk Museum, Copenhagen

ZSM Zoologisch Staatssammlung, München

CJH collection of José María Hernández, Gran Canaria

CER collection of Emilio Rolán, Vigo

CFF collection of Francisco Fernandes, Santa Rita, Portugal

CFS collection of Frank Swinnen, Lommel, Belgium

CMP collection of Marcel Pin, Dakar, Senegal

CPR collection of Peter Ryall, Maria Rain, Austria

sp specimen with soft parts

s shell empty

j juvenile

## RESULTS

Genus *Nassarius* Duméril, 1806

*Nassarius denticulatus* (A. Adams, 1852)  
(Figs 1-6)

*Nassa denticulata* A. Adams, 1852. *Proc. Zool. Soc. Lond.*: 110. [Type locality: unknown].

*Nassa prismatica*: sensu Aradas & Benoit, 1870. *Atti Acad. Goenia Sci. Nat. Cat.*, p. 292, pl. 5 fig. 12 (non Brocchi, 1814).

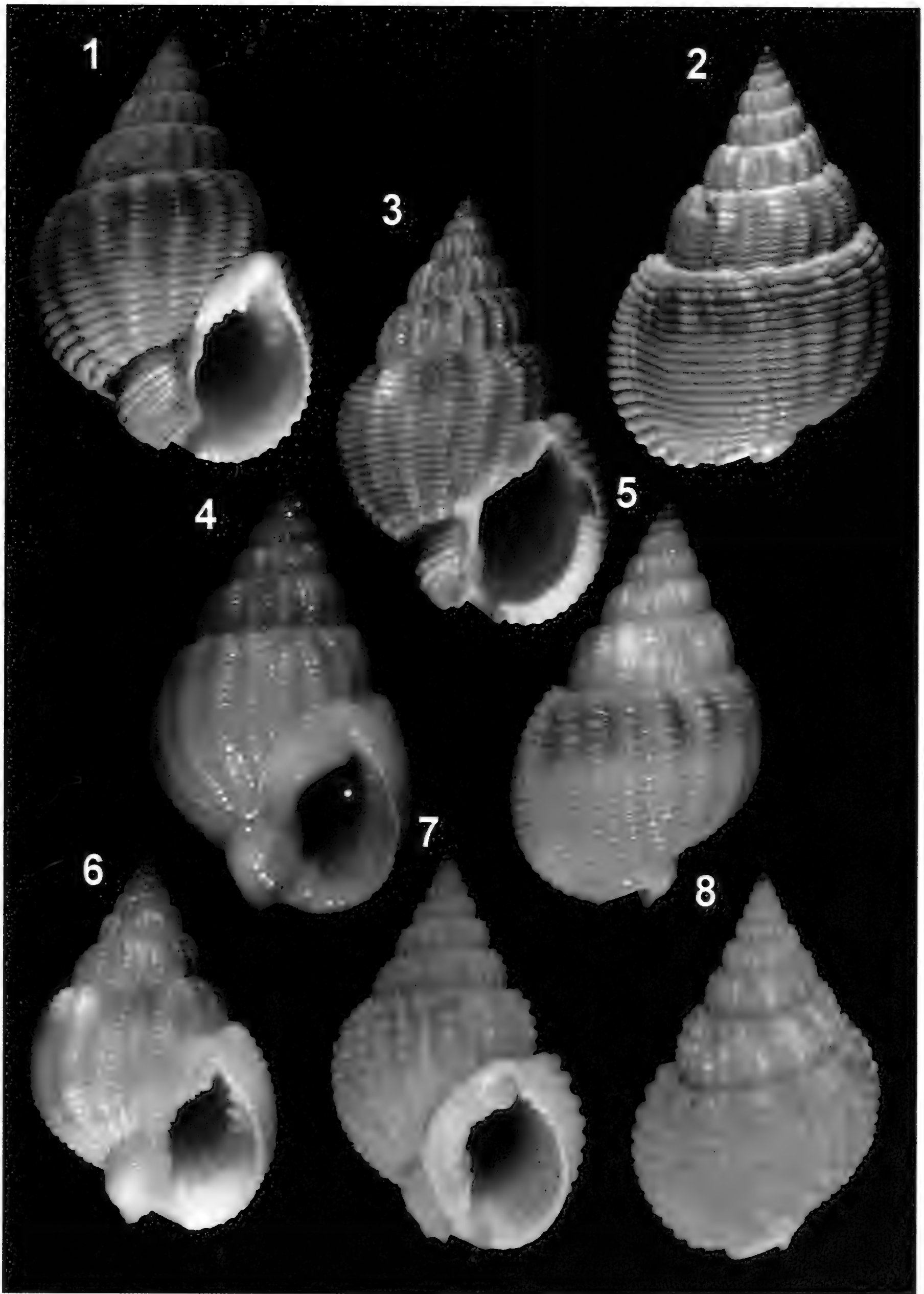
*Nassa limata* var. *conferta* von Martens, 1876. *Jahrb. deut. Malak. Gessell.*, 3: 239, pl. 9, fig. 3 [Type locality: near Cape Verde islands, 16°40'N 23°04'W, 86 m].

*Nassa renovata* Monterosato, 1878 (*nomen nudum*). *Giorn. Sci. nat. Econ.*, 13: 103.

**Type material** A syntype of *N. denticulatus* was illustrated in Cernohorsky (1975, p. 153, figs 67), and later, Morán *et al* (1989, p. 41-43), designated one of the syntypes as lectotype and represented the lectotype and paralectotype (figs 9, 10). This type material is in BMNH (1894175).

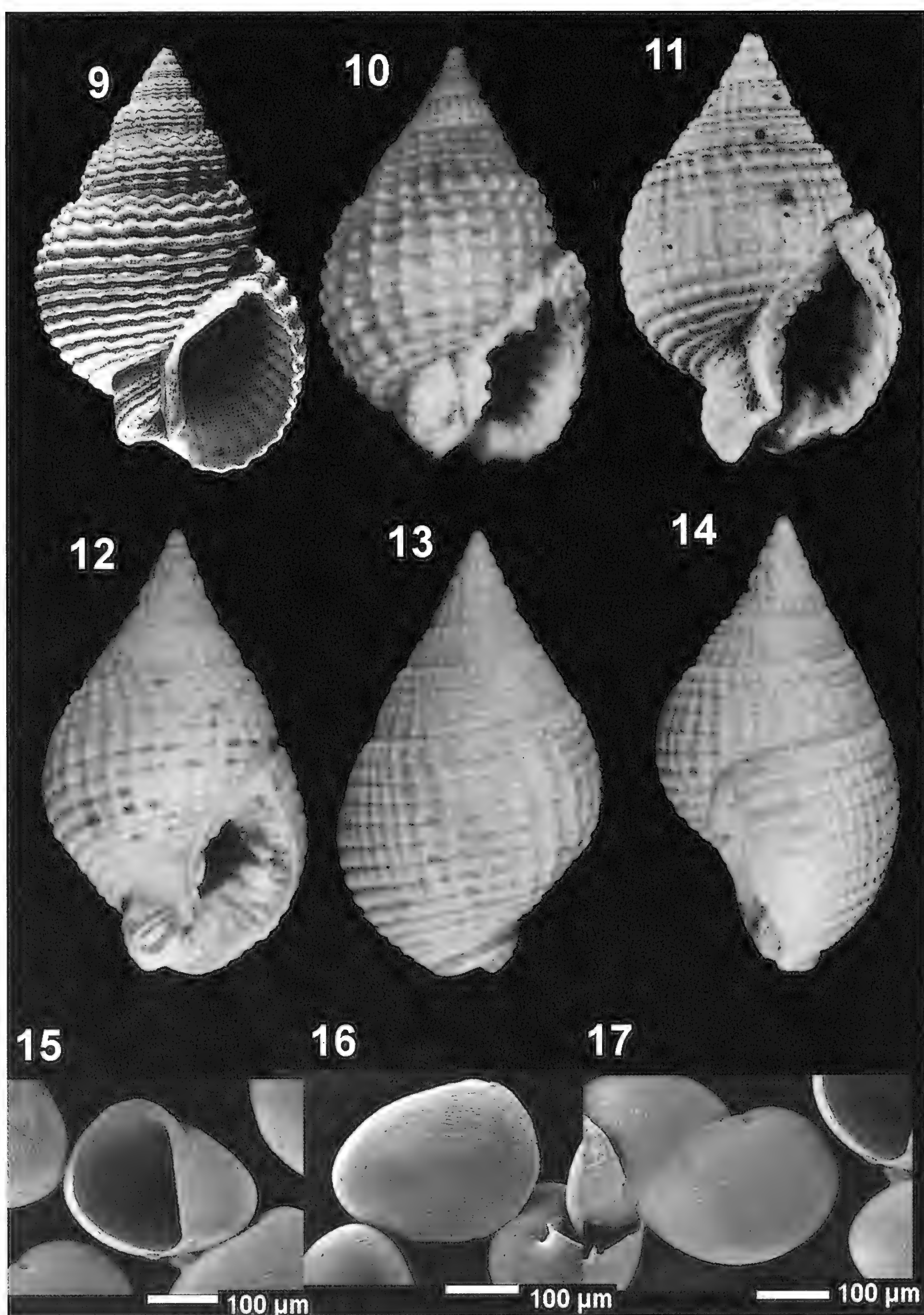
**Other material studied** **Madeira**: 1 sp, off Funchal, (CJH, ex CFS); 2 s, NO Jean Charcot ZARCO, SW Desertes 32°38.9'N 17°05.0'W, 220-300 m (MNHN); 1 s, NO Jean Charcot ZARCO, SW Desertes 32°28.1'N 16°31.6'W, 200-250 m (MNHN); 1 s, NO Jean Charcot ZARCO, Porto Santo 33°00.7'N 16°25.5'W, 220-290 m (MNHN). **Canary Is.**: 2 sp, NW Gran Canaria, 150-200 m (CJH); 1 s, Cofete, Fuerteventura (CJH); 4 sp, NW Gran Canaria (28°02.020'N 15°48.930'W), dredgings 70-80 m (CJH); 1 j, NW Gran Canaria (28°04.319'N 15°52.408'W), dredgings, 105 m (CJH); 1 sp, NW Gran Canaria (28°07.018'N 15°50.780'W), dredgings, 180 m; 1 j, off Tacoronte, Tenerife, 93-95 m (CJH); 2 sp, off Candelaria, Tenerife, in nets, 180 m (CJH); 2 s, off Tenerife, fish-traps, 150-300 m (CER); 2 s, Santa Cruz de La Palma, 100 m (CER). **Morocco**: 1 s, Ceuta, Anse Almadraba, 35°52.5'N 05°19.0'W, 35-45 m (MNHN); 6 s, Melilla, fishermen (CER); 1 s, south Morocco, fishermen, 70 m (CER). **Spain**: 20 s, Malaga, industry dredgings, 20-40 m (MNHN). **Alger**: 2 s, Oral Gulf (MNHN).

**Sahara**: 2 sp, off Sahara Coast (22°35'N 16°58'W), trawled, 48 fms (CJH); 1 s, fishermen dredgings (CER). **Mauritania**: 3 sp, (17°30'N 16°17'W), from fishermen, 70-100 m (CJH); 3 sp, 150-300 m (CJH); 1 s, fishermen, 150 m (CER). **Senegal**: 1 sp, off Mbour, 40-50 m,



**Figures 1-6** *Nassarius denticulatus*. 1-2 28.6 mm, Melilla, Morocco (CER). 3 28.5 mm, Mauritania (CJH). 4-5 20.8, 19.4 mm, NW Gran Canaria, Canary (CJH). 6 19.4 mm, Mauritania (CJH). **Figures 7-8** *Nassarius cf. arcadioi*, São Vicente, Cape Verde (from GUERREIRO & REINER, 2000).





**Figure 9** *Nassarius clathratus*, 30.6 mm, fossil of the Miocene, Roero, Italia (from CAVALLO & REPETTO, 1992). **Figure 10.** *Nassarius webbei*, holotype, 17.3 mm, Senegal (MNHN) (from ADAM & KNUDSEN, 1984). **Figures 11-14.** *Nassarius turbineus*. **11** 19.8 mm, 4°50'N 2°49'W (ZMUC) (from ADAM & KNUDSEN, 1984). **12-14** 20.3 mm, 5°37'N 0°38'E (CER). **Figures 15-17** larval shells of *Nassarius arcadioi*, from a paratype (MNHN).

CJH ex-CMP); 15 sp, Abéné, N. Casamance, 13°01.8'N 17°25.5'W, 53 m (MNHN). **Cape Verde Is.:** 50 sp, off Curral Velho, Boavista, 40-100 m (DBUA). **Ghana:** 1 sp, Cape Coast (CJH ex-CPR). **Angola:** 4 sp, Luanda, 60 m, dredgings (CJH ex-CFF); +400 sp and s, Ilha de Luanda, 40-60 m (MNHN); 15 s, 6 j, Praia Amelia, 40-60 m (MNHN) .

*Diagnosis* It is a well known shell (Figs 1-6). In Adam & Knudsen (1984), *Nassarius denticulatus* is described in pages 11-13, and illustrated in figures 5-6 (shell), A5 (operculum), B4 (radula) and Plate I figures 5-6 (shells from Luanda, Angola and Tema, Ghana). This species was also mentioned in von Martens (1876, as *N. limata* var. *conferta*), Monterosato (1878 as *N. renovatus*, 1880), von Martens (1881), Tryon (1882), Locard (1886 pars as *Nassa limata*, 1897), Kobelt (1887a), Dautzenberg & Fischer (1906), Hidalgo (1917), Pallary (1920), Nobre (1940), Knudsen (1956), Marche-Marchad (1958), Pasteur-Humbert (1962), Cernohorsky (1975), Adam & Knudsen (1984), Nofroni (1987), Morán *et al* (1989), Aparici Seguer & García Carrascosa (1996)(illustrated), Rolán & Ryall (1999), Giannuzzi-Savelli *et al* (2003), Rolán (in press).

In Kaicher cards, *N. denticulatus* appeared as n° 3169.

*Distribution* The distribution of *N. denticulatus* is wide, extending to northern African coasts, reaching the Western Mediterranean, Canary Islands, Madeira and the Cape verde Islands, along the west African coast to Angola.

*Remarks* This species is widely known and there are no problems with its diagnosis. For the differences with *N. desmoulioides* see below.

***Nassarius turbineus* (Gould, 1845)**  
(Figs 11-14)

*Nassa turbinea* Gould, 1845. *Proc. Boston Soc. Nat. Hist.*, 2: 37. *Boston J. Nat. Hist.*, 5: 292, pl. 24, fig. 10. [Type locality: Liberia, West Africa].

*Type material* The holotype of *N. turbineus* could not be located, and in Kaicher's card n° 4175 a specimen from ZMUC has been represented. Due to the necessity of establishing an indubitable type for this taxon we designate this shell the neotype of the species *N. turbineus*.

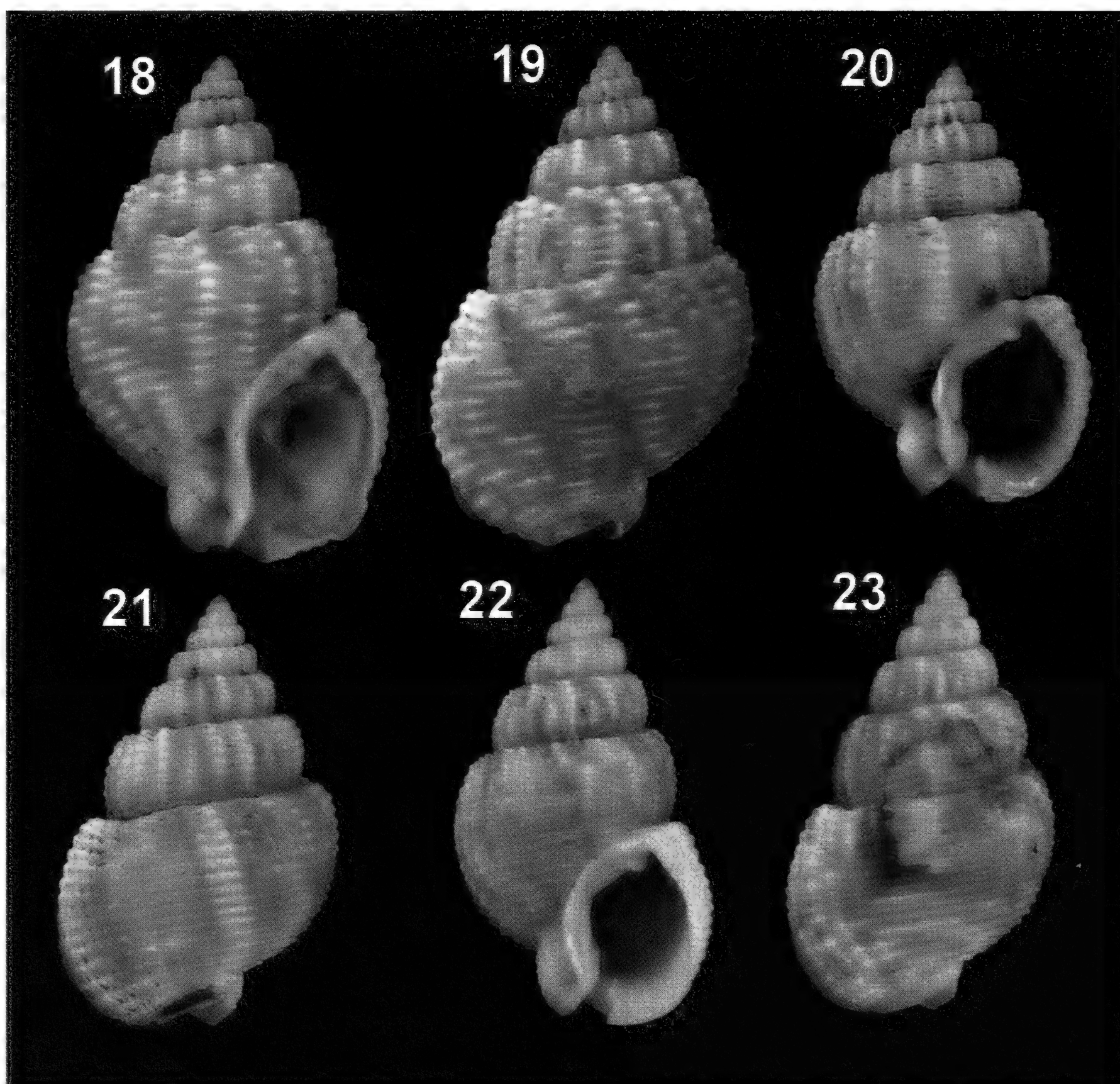
*Other material studied* **Ivory Coast:** 3 s, 2 j, Abidjan region (MNHN). **Ghana:** 1 s, 4 f, 2 j, off Cape Three Points, 35-65 m (CER). **Guinean Gulf:** 1 s, Atlantide Exp. (5°37'N 0°38'E), 50 m, mud bottom (CER) (Figs 12-14); 1 s, Atlantide Exp. (5°37'N 0°38'E), 50 m (MNHN); 1 s, Calypso 1956, St. 56, 0°38'25"S 8°46'E, 5 m (MNHN) 1 s, Calypso 1956, St. 12, 6°40'S 11°23'E, 51 m (MNHN).

*Diagnosis* *N. turbineus* is described and illustrated in Adam & Knudsen (1984); the spire in text-fig. 45, the operculum in fig. A 18, and the shell in pl. 3, fig. 9. This species is mentioned as similar to *N. desmoulioides*, but the protoconch has only 1 ¼ - 1 ½ whorls. Also *N. turbineus* has been mentioned in Marrat (1880), Tryon (1882), Odhner (1923) Knudsen (1956) and Marche-Marchad (1958).

*Distribution* The distribution of this species appears to be relatively limited, with the material coming from Liberia (the type locality) and several localities from the Gulf of Guinea (Adam & Knudsen, 1984).

*Remarks* *N. turbineus* is clearly different from other species of the group.





**Figures 18-23** Types of *N. desmoulioides*, Umhloti River, Natal (BMNH). **18-19** Lectotype, 21.4 mm. **20-23** paralectotypes, 18.3 and 19.0 mm,.

*Nassarius webbei* (Petit de la Saussaye, 1850)  
(Fig. 10)

*Buccinum (Nassa) webbei* Petit de la Saussaye, 1850. *J. Conchyl.*, 1: 404, pl. 13, fig 8. [Type locality: coast of West Africa in description, Senegal on the label of the holotype].

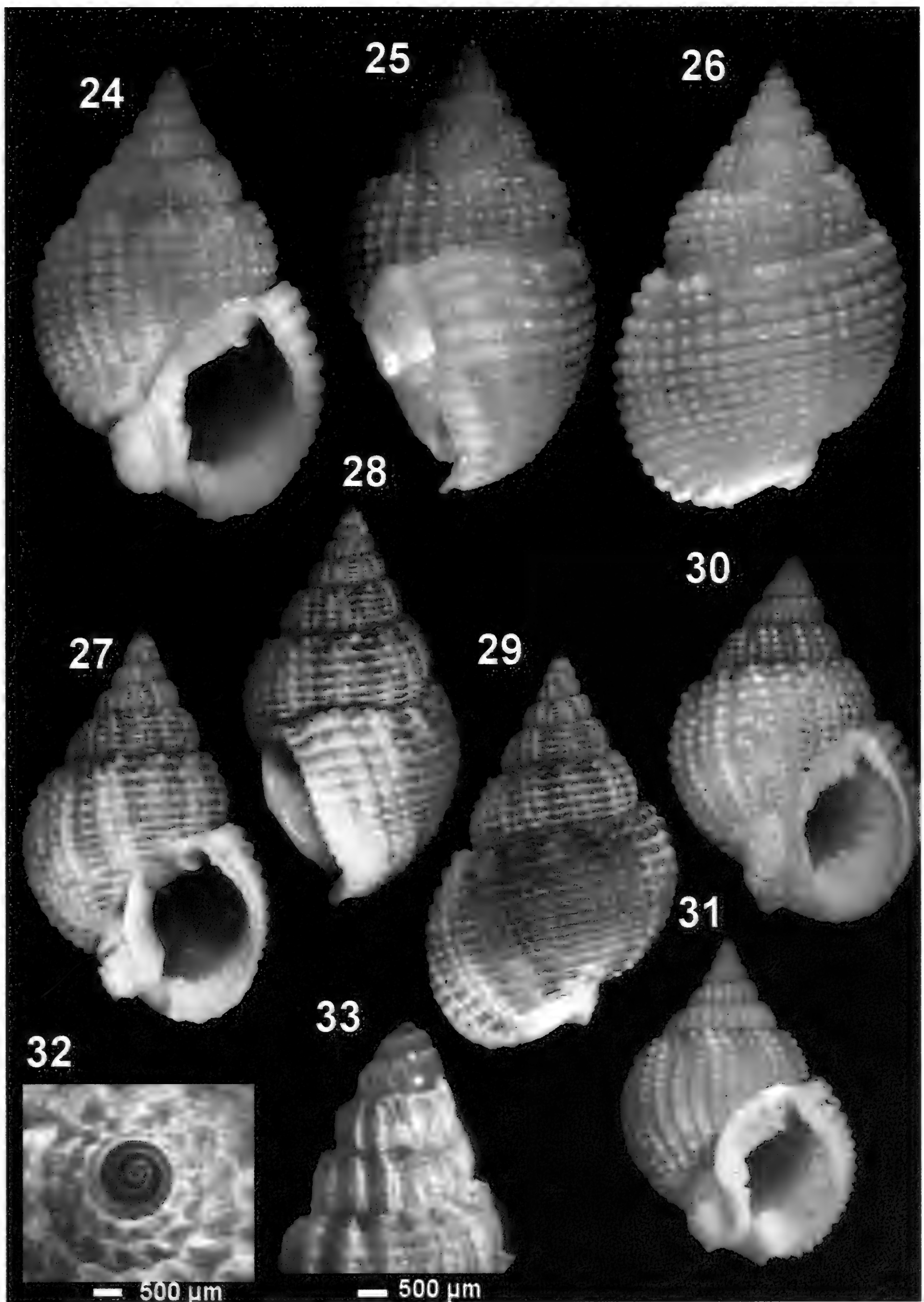
*Type material* Holotype in MNHN represented in Adam & Knudsen (1984, pl. 3, fig. 10) (Fig. 10).

*Diagnosis* See description in Adam & Knudsen (1984). The species has been represented in Kaicher's card n° 3556.

*Distribution* Apparently, this species has a limited range of distribution being known only from Senegal.

*Remarks* *N. webbei* has been synonymized by Cernohorsky (1984) with *N. turbineus*. The holotype of *N. webbei* (MNHN) has been represented in Kaicher's card n° 3556 and also in Adam & Knudsen (1984, pl. 3, fig. 10). It evidently seems to be a different species from *N. turbineus*, mainly by the nodules in basal cords. The most important differences





Figures 24-27 *Nassarius arcadioi*. 24-26 holotype, 25.1 mm, Mauritania (MNCN). 27-29 paratype, 23.3 mm (MNHN). 30 paratype, 21.3 mm (AMNH). 31 paratype, 18.9 mm (CJH). 32-33 protoconch of a paratype, (MNHN).

are that in *N. webbei* the number of the axial ribs and the number of the nodulous spiral cords are less than in *N. turbineus*, the cords separated and with wider interspaces; the protoconch of *N. webbei* has 2 smooth whorls, being more prominent and with a poorly visible separation from the teleoconch, as is mentioned in Adam & Knudsen (1984) who also consider it a different species from *N. turbineus*. Both are represented species in plate 3, figs 9 and 10.

*Nassarius clathratus* (Born, 1778)  
(Fig. 9)

*Buccinum clathratum* Born, 1778. *Ind. rer. nat. mus. Caes. Vindob.*, Pt. 1: 225. Born, 1880. *Test. Mus. Caes. Vindob.* p. 9, figs 17, 18. [Type locality: fossil European].

*Nassa turrita* A. Adams, 1852. *Proc. Zool. Soc. Lond.*, 1851, Pt. 19: 110 (*non* Borson, 1820). [Type locality unknown].

*Type material* Born material not examined. *N. turrita* (BMNH), syntype represented in Cernohorsky (1975).

*Diagnosis* See description in Chirli (2000). A shell from Roero is shown (Fig. 9).

*Remarks* *Nassarius clathratus* has been noted as a Canary Islands species by Nordsieck & García-Talavera (1979). This species also appears in the CLEMAM list for the recent European fauna. It was described from the Tuscan Pliocene, and it has been represented in Cernohorsky (1975), in Cavallo & Repetto (1992) and in Chirli (2000), and recorded for the Pliocene of Estepona (Vera-Peláez *et al.*, 1995). In this latter work the shells could belong to two species: fig. 12, similar to the syntype of *N. turrita*, and figs 9-11 and 13-14, a little different.

Few recent records were mentioned in Nobre (1940): only a fragment by Kobelt (1887b, p. 462) for the Lusitanian Sea and other shell referred by von Martens (1876) as being West African. As this species has not been mentioned in any other work and the record of Nordsieck & García-Talavera (1979) is evidently based on a shell of *N. denticulatus*, we conclude that this species is only known as fossil and that it is not in the recent West African or European fauna.

*Nassarius desmoulioides* (Sowerby, 1903)  
(Figs 18-23)

*Nassa desmoulioides* Sowerby, 1903. *Mar. Invest. Sth. Africa*, 2: 219, pl. 4, fig. 1. [Type locality: Umhloti river mouth (Natal), South Africa, 183 m].

*Type material* Lectotype in BMNH selected and illustrated in Cernohorsky (1984, pl. 7, fig. 13) and in Morán *et al.* (1989, fig. 7); also a paralectotype (as paratype) was represented in Adam & Knudsen (1984, pl. 1, fig. 7). We show here the lectotype and paralectotypes (Figs 18-23) (Reg. n°. 1903.7.27.80-82).

*Diagnosis* See description in Cernohorsky (1984) and in Morán *et al.* (1989). The species has been referred to in Smith (1906), Tomlin (1928), Barnard (1959), Kensley (1973), Adam & Knudsen (1984), Cernohorsky (1984) and Rolán & Ryall (1999). Also the species has been shown in Kaicher's card n° 3463. The records of West Africa in Adam & Knudsen (1984) and in Rolán & Ryall (1999) belong to another new species described below.

*Distribution* In our opinion this species has been recorded only from South Africa,

actually the East Coast (Natal). The West African records are attributable to the new species, which will be described below.

*Remarks* As mentioned in the introduction, in Adam & Knudsen (1984) there is an apparent discrepancy: the plate 1, fig. 7 (paratype of *N. desmoulioides*) from South Africa is not the same species as the shell in plate 1, fig. 8 and the text-fig. 11. These latter belong to the new species.

The first doubts about the identity of these two species were felt by Barnard (1959: 116). Later, Morán *et al* (1989) made comparison of *N. denticulatus* found in Cape Verde islands and both lectotypes of *N. denticulatus* and of *N. desmoulioides*. After this comparison, they presented a plate with a summary of the numerical characters of both lectotypes and paralectotypes. Their conclusion is that both are very similar and only due that short material from the second taxon was examined, they could not ascertain if they were the same species.

It may be considered that both lectotypes of *N. denticulatus* and *N. desmoulioides* may be same species (as Morán *et al*, 1989 had pointed out). But some different characters convinced us that they must be different:

-*N. denticulatus* is usually larger and wider; the juveniles are also wider.

-There are differences in color: *N. denticulatus* has a subsutural band predominating on a cream shell, while *N. desmoulioides* (lectotype, paralectotypes and the shell in Kaicher' card) have a more scattered pigmentation on the shell. These differences could be included within an intraspecific variation, but all the shells from West Africa have very uniformly the subsutural band never is present the typical pattern of the South African *N. desmoulioides*.

-The number of spiral cords is about 21 in *N. denticulatus* being narrower than those present in the types of *N. desmoulioides*, which are 16-18.

-The intersections between cords and ribs are more elevate in *N. desmoulioides* than in *N. denticulatus*.

-Finally, it is very uncommon that one species may be present in all West African coasts and also in the Indian Ocean.

For all these reasons we conclude that both taxa are different species, *N. denticulatus* from Mediterranean to Angola, and *N. desmoulioides* from South Africa.

*Nassarius arcadioi* spec. nov.  
(Figs 24-33)

*Nassarius desmoulioides* auct. (non Sowerby, 1903).

*Type material* Holotype (Figs 24-26) in MNCN (15.05/46623); paratypes in AMNH(1)(Fig. 30), BMNH(1), MNHN(1)(Figs 27-29), ZSM (1), MNHST (1)(Fig. 31), and collection of the authors (CER and CJH, 5 in each), all from off Mauritania, 50-300 m.

*Other material studied* **Mauritania:** 1 s, NO N'Diogo, St. 175, 17°12'N 16°38'W, 140 m (MNHN); 1 s, NO N'Diogo, St. 247, 17°54'N 16°23'W, 99 m (MNHN); 3 sp, trawled by fishermen, 60-70 m (CER); 2 sp, trawled by fishermen, 80-100 m (CER); 4 j, off Mauritania (19°10'N 16°55'W), from fishermen, 45 fms (CJH); 3 sp, off Mauritania (20°10'N 17°28'W), from fishermen, 300 m (CJH). **Senegal:** 1 s, off Saint Louis, 300-600 m, from fishermen (CJH ex-CMP); 7 s, off Saint Louis, 600-1000 m (MNHN); 5 s, along Gorée, 50 m (MNHN); 5 s, Dakar, 150-200 m (MNHN); 5 s, Dakar, 14°47'N 17°34'W, 135 m (MNHN); 19 s, 12 j, S Gorée, 95-98 m (MNHN). **Ivory Coast:** 6 s, 200 j (MNHN). **Guinean Gulf:** 5 s, Calypso 1956, 5°21.5'N 9°54.5'W, 73-80 m (MNHN). **Angola:** 3 sp, Corimba, Luanda, 40 m (CER); 9 s, Palmeirinhas, Luanda, 60-80 m (MNHN); 1 sp, 3 s, Ilha de Luanda, 50 m



(CER); 1 sp, 2 s, 10 j, Ilha de Luanda, 90 m (MNHN); 4 s, Cacucaco, Luanda, 60 m (CER); 2 sp, Luanda, 80 m (CER); 3 sp, 4 s, along Mussulo, Luanda, 40-60 m (MNHN); 10 s, 8 j, Praia Amelia, 40-60 m (MNHN); 2 s, Praia Amelia, 50 m (CER).

*Type locality* Off Mauritania, 200-300 m.

*Derivation of name* The species is dedicated to Arcadio Benítez Galván from Agaete, Gran Canaria, an excellent collector of malacological material and sediments from West Africa and the Canary Islands.

*Description* Shell (Figs 24-31) solid, in form almost spherical with a pointed spire, large body whorl. Protoconch (Figs 32, 33) dark brown of planktotrophic type with  $2\frac{1}{4}$ - $2\frac{1}{2}$  smooth whorls, and a diameter of 1.2 mm. Teleoconch of 5-6 convex whorls, with a deep suture more sunken than the first nodular cord of the lower whorl, being separated from it by a smooth canal. The last whorl is very large and wide representing the  $\frac{2}{3}$  of the height. The whorls have 12-15 axial ribs in first one, 12-16 in the second and 30-41 in the last one. These ribs are smaller and more numerous in the last quarter of the body whorl. They are crossed by spiral cords forming rounded and prominent nodules in the crossing points, mainly in the upper part of the whorls. The number of the spiral cords is 6-7 on the first whorl, 7-9 in the second and 15-19 on the last one. A canal separates the lower part from the siphonal wall. Aperture moderately wide, outer lip thick, with 15-17 lirae on the outer lip, which extend internally; columella curved, denticulate, and with a prominent parietal cord on the upper part and 2 in lower part, one of them wider. Columellar callus strong, moderately narrow, regularly bordered and laminate anteriorly. Near the end of the spire there is a thick but poorly defined enlargement.

Creamy white in color, ornamented with orange-brown, regular blotches, usually evident in subsutural area forming axial bands, which are not always well defined and sometimes visible only as irregular brown spots in two spiral bands on the last whorl.

Dimensions. The holotype is 25.1 x 16.1 mm, and the larger specimens had 28.4 mm.

Animal. We have no information on the living animal.

Radula. We have examined the radula of this species but we do not illustrate it because a good drawing of it was published by Adam & Knudsen (1984, fig. B5).

Operculum. Also illustrated in Adam & Knudsen (1984, fig. A6).

Larval shells: during the study of the radula, one female was extracted having numerous larval shells near hatching (Figs 15-17). Obviously it is a ovoviviparous species. The larvae are globose, with about one whorl, with the external surface covered by spirally arranged tubercles and lines; aperture semicircular.

*Distribution* Adam & Knudsen (1984, text-fig. 11, plate 1, fig. 8) represent shells of *N. arcadioi* as *N. desmoulioides*; we accept the localities they mentioned because the description, radula and operculum therein represented are from West Africa. So, the localities in which they mention that this species was found are correct: from Gabon to Angola. Our material confirms this presence from Mauritania down to Angola. Shells probably of this species have been collected in the Cape Verde Islands (Guerreiro & Reiner, 2000, presented as *Nassarius pelicatus* Adams, 1854, and Rolán, in press).

*Discussion* The name *N. pelicatus* Adams, 1845, employed for some shells probably of this species, does not exist. It was neither mentioned in any paper, nor present in the revision of the names of Adams (Trew, 1992: 48) and not any type in BMNH. Probably, it is an error from *N. plicatellus* (A. Adams, 1852). This species is from south of Angola to South Africa (Cernohorsky, 1984) and is different from the group here studied.

The shells of *N. arcadioi* spec. nov. have usually been considered as *N. desmoulioides* by

collectors and dealers. In the authors' opinion, this is due to the fact that the name *N. desmoulioides* has been erroneously interpreted and so, we now have two species: one, the true *N. desmoulioides*, which corresponds with the types from Natal, South Africa, and another previously unnamed species which inhabits the West African coast, being described herein as *N. arcadioi*.

It is surprising that after the types of *N. desmoulioides* were illustrated, nobody realised that they did not correspond to the West African shells now described as *N. arcadioi*. We consider evident that the shells of the species here described are different from the lectotype of *N. desmoulioides* from South Africa, *N. arcadioi* having a different profile, a larger shell, being wider at the last whorl, the suture deeper, the spiral cords more evidently nodulous, the axial ribs more rectiline and more numerous, the columella more denticulate and the columellar callus more prominent.

The shells illustrated by Guerreiro & Reiner (2000) and copied in Rolán (in press) from the Cape Verde islands, are probably *N. arcadioi*, but the photos show a shell with some small differences as the axial ribs and spiral cords which are fewer in number and more widely spaced. This material was lost (Guerreiro pers. comm.) and it could not be examined.

There is no problem with the differentiation of *N. arcadioi* and *N. denticulatus*, as their differences are very evident. Both species have been separated over the years by collectors and dealers: *N. denticulatus* has more spiral cords which are narrower, lacking nodules at the intersections of the cords with the axial ribs; has a thicker, shorter and well defined external enlargement; has the brown colored subsutural band instead of axial bands. Both species, *N. arcadioi* and *N. denticulatus*, have a rather similar distribution: the former from Mauritania to Angola, both being coincident in this area. In the places where both species were found in sympatry, *N. arcadioi* was dredged from deeper water than *N. denticulatus*.

*N. turbineus* has only  $1\frac{1}{4}$  -  $1\frac{1}{2}$  whorls of protoconch, while the shells of *N. arcadioi* have a protoconch of  $2\frac{1}{4}$  -  $2\frac{1}{2}$  whorls, besides the differences in the shell mentioned in Adam & Knudsen (1984) being that *N. turbineus* has fewer spiral cords which are wider than the intervening spaces, with depressed nodules, the intersections shaped like rectangles and a narrower aperture.

*N. webbei* may be differentiated from *N. arcadioi* because of its spiral cords and also that the axial ribs are less in number and more separate, and that the aperture is narrower and the protoconch has only 2, more prominent whorls.

*N. clathratus* is a fossil species, probably not present in the recent fauna. In any case, *N. arcadioi* has a more solid shell than *N. clathratus*, the last whorl is wider, has more spiral cords, (15-19 in *N. arcadioi* versus 11-15 in *N. clathratus*) and the nodules at the intersections are evident.

#### ACKNOWLEDGEMENTS

We would like to thank Kathie Way, Amelia MacLellan and Phil Crabb of The Natural History Museum of London for the photos of the types of *N. desmoulioides*. Also we thank Karel Wouters, Editor-in-Chief of the Bulletin Institut Royal des Sciences naturelles de Belgique, to Gianni Repetto, author of *Conchiglie fossili del Roero*, and António Guerreiro, author of *Molluscs of S. Vicente*, who gave us authorization for publication of some photos from their books. To Philippe Bouchet and Virgine Heros for the examinations of MNHN's collections. The color photographs were taken in the Department of Ecology of Jesús S. Troncoso in the University of Vigo. Jesús Méndez of the CACTI of the University of Vigo took the SEM photos.

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# BAPTODORIS PERUVIANA (D'ORBIGNY, 1837) COMB. NOV., AN ALTERNATIVE TAXONOMIC PLACEMENT FOR DORIS PERUVIANA (GASTROPODA: NUDIBRANCHIA: DORIDOIDEA).

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*Abstract* Placement of the nominal species *Doris peruviana* D'Orbigny, 1837 within the genus *Platydoris* Bergh, 1877 has been proposed recently, under the assumption of the junior synonymy of *P. punctatella* Bergh, 1898. However, *D. peruviana*'s type material cannot be located. The comparison of specimens of a doridoidean species from Iquique to Los Molles (Chilean coast) with the *P. punctatella*'s holotype has led us to conclude that both material are conspecific and, according to the radular features, belonging to the genus *Baptodoris* Bergh, 1884 instead of *Platydoris*. Since *P. punctatella*'s holotype is perserved poorly, except its radula, a neotype for *B. peruviana* comb. nov. is designated.

*Key words* Nudibranchia, Discodorididae, *Baptodoris peruviana*, taxonomy, neotype.

## INTRODUCTION

The opisthobranch fauna of the Chilean coast still needs further study, in spite of several expeditions during which specimens were collected (Bergh, 1884; Bergh, 1894; Bergh, 1898; Dall, 1890; Lesson, 1831; D'Orbigny, 1837; Marcus, 1959; Odhner, 1921; Odhner, 1926). In fact, new species have been described recently (Millen, Schrödl, Vargas & Indacochea 1994; Schrödl, 1996a, 1996b, 1999; Fischer, Cervera & Ortea, 1997).

However, the three reviews of the opisthobranchs from Chile, by Marcus (1959) and Schrödl (1996a; 2003) overlook the genus *Baptodoris* Bergh, 1884. Bergh (1884) introduced the genus *Baptodoris* based on the type species *B. cinnabarina* Bergh, 1884. Since then the genus has been included in several families, Dialulididae by Bergh (1891), Baptodorididae by Odhner (1926), Platydorididae by Ortea, Pérez & Llera (1982), Dorididae by Schmekel & Portmann, (1982) and Discodorididae by Gosliner, (1991), but without a solid phylogenetic basis. The taxonomy of this problematic taxon was recently clarified by Valdés (2002), based on a phylogenetic analysis of the cryptobranch dorids, which brings 13 family-level taxa under the synonymy of the family Discodorididae Bergh, 1891, and the latter was proposed as a valid name for the family based on the principle of first reviser (ICZN, 1999: Article 24) instead of Dialulididae, Kentrodorididae and Platydorididae described at the same time by Bergh (1891). The genus *Baptodoris* Bergh, 1884 is closely related with the genera *Gargamella* and *Platydoris* (Valdés & Gosliner, 2001). Garavoy, Valdés & Gosliner (1999) present a phylogenetic hypothesis in which *Platydoris* and *Baptodoris* are sister groups, and this clade is the sister group of *Gargamella*. This hypothesis is also supported by Valdés and Gosliner (2001).

A new diagnosis of the genus *Baptodoris* was recently presented by Valdés and Gosliner (2001). Following the above phylogenetic hypothesis, three valid species of this genus have been considered in the world at the moment, *Baptodoris cinnabarina* from the western Mediterranean Sea, *B. mimetica* Gosliner, 1991 from California and *B. phinei* Valdés, 2001 from the Coral Sea, close to New Caledonia. Moreover, Dorgan, Valdés & Gosliner (2002) consider that *Platydoris stomascuta* Bouchet, 1977 should be considered as *Baptodoris*.

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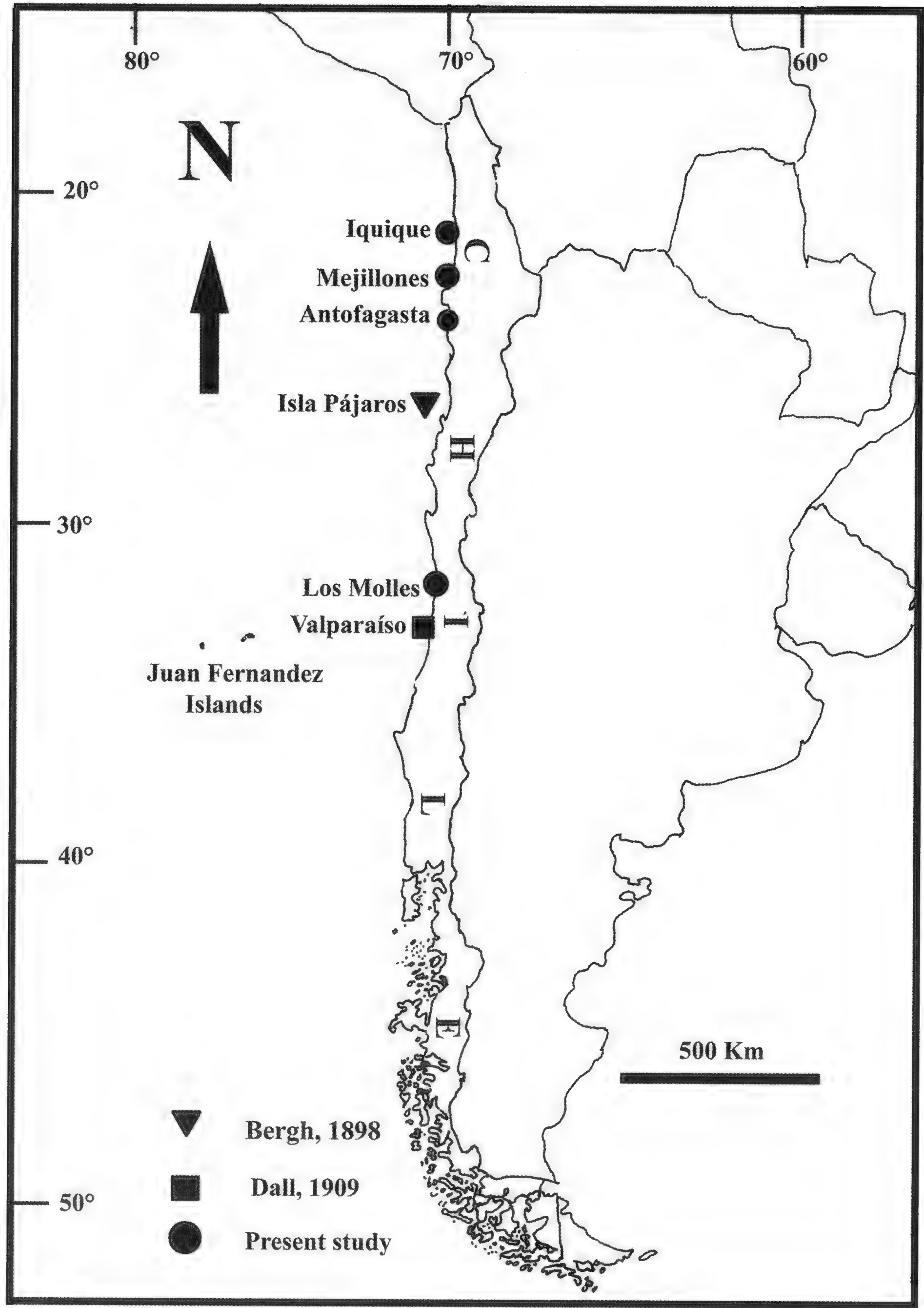


Figure 1 Geographic distribution of *Baptodoris peruviana* in Chile.

Recently, Schrödl (2003) has assigned the d'Orbigny's species *Doris peruviana* (1837) to the genus *Platydoris*. This species was very poorly described, based only on the external morphology. Its geographical distribution is thought to range from south of San Lorenzo Island, Lima, Perú (d'Orbigny, 1837) to Valparaíso, Chile (Dall, 1909). The record from Tagus Cove, Albemarle, Galápagos (Pilsbry & Vanatta, 1902) seems to be doubtful. Schrödl (2003) included also *P. punctatella* Bergh, 1898 within the synonymy of *P. peruviana*, although Dorgan, *et al.* (2002) excluded this last from *Platydoris* on the basis of the external appearance of the living animal photographed by Schrödl (1996a, as *P. punctatella*). *Platydoris punctatella* ranges from Pucasana, Perú (Schrödl, 1996) to Isla Pajaro in Chile (Bergh, 1898).

The present study provides stronger evidences to remove d'Orbigny's *Doris peruviana* from *Platydoris* and to include it within *Baptodoris*, as well as constitutes the first record of this genus from the Chilean coast.

### SYSTEMATIC DESCRIPTION

DORIDOIDEA Pelseneer, 1894

CRYPTOBRANCHIA Fischer, 1883

LABIOSTOMATA Valdés, 2002

Family Discodorididae Bergh, 1891

Genus *Baptodoris* Bergh, 1884

TYPE SPECIES: *Baptodoris cinnabarina* Bergh, 1884

*Baptodoris peruviana* (D' Orbigny, 1837) *comb. nov.*  
(Figures 1-8)

*Doris peruviana* D' Orbigny, 1837: 188, pl. XV, figs 7-9.

*Doriopsis peruviana* Dall, 1909: 203

*Dendrodoris peruviana* (D' Orbigny, 1837): Álamo & Valdivieso, 1987: 91

*Platydoris punctatella* Bergh, 1898: 521-523, figs. 12-20; Dall 1909: 203; Marcus, 1959: 88; Schrödl, 1996a: 23, pl. IV, fig. 27

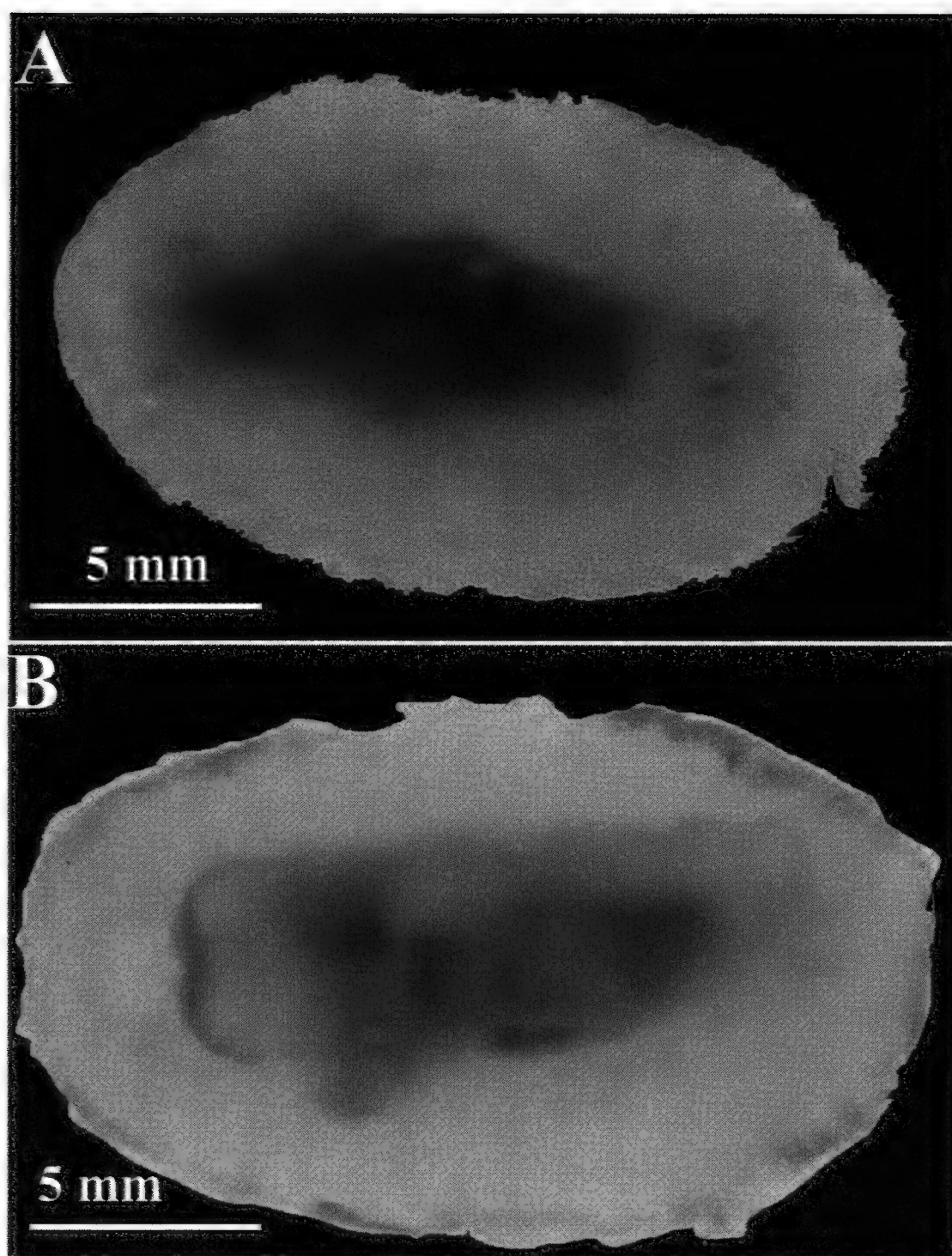
*Argus punctatella* (Bergh, 1898): Carcelles & Williamson, 1951: 317

*Platydoris peruviana* (D' Orbigny, 1837): Schrödl, 2003: 34-35, figs. 17, 54, 71.

### MATERIALS AND METHODS

Material studied in this paper was housed in the "Colección de Flora y Fauna Profesor Patricio Sánchez Reyes" ("Pontificia Universidad Católica de Chile")(SSUC), except the holotype of *Platydoris punctatella* Bergh, 1898. For identification purposes, the material was studied on the basis of external morphology and anatomical features. Labial cuticle, radula, surface of the notum and reproductive system were examined by light microscopy, and subsequently by Scanning Electron Microscopy (SEM). Soft structures (the penis, deferent duct and surface of the notum) were subjected to critical point drying before using SEM.

*Doris peruviana* d'Orbigny, 1837, neotype (here designated): One specimen 22 mm preserved length, Iquique (20°12'S; 70°10'W), February 1965, Museum number SSUC-6977.



**Figure 2** Specimen of *Baptodoris peruviana* of 15 mm (preserved) from Mejillones. A Dorsal view  
B Ventral view.

*Additional material* Iquique (20°12'S; 70°10'W), February 1965, Museum number SSUC-3332: two specimens 16 and 7 mm preserved length. Southwest of the Mejillones peninsula Peninsula (23°20'S; 70°34'W): twelve specimens, 6-26 mm preserved length, Museum number SSUC-3032. La Portada, Antofagasta (23°39' S; 70°25' W), January 1965, Museum number SSUC-2607: three specimens, 12-21 mm preserved length. Los Molles (32°15'S; 71°30'W), February 1962, coll. Alberto Carvacho, Museum number SSUC-183: three specimens, 8-16 mm preserved length.

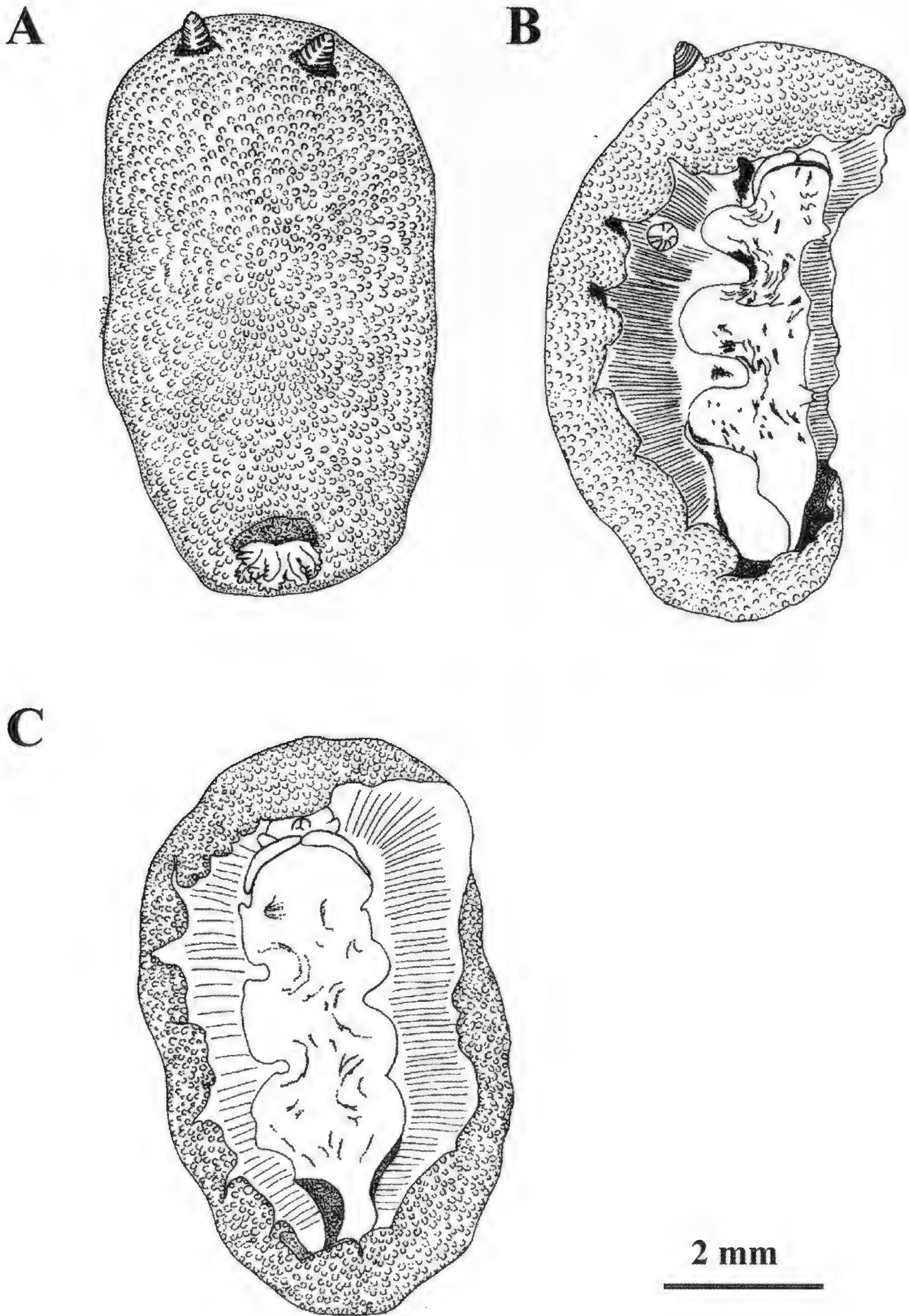
*Platydoris punctatella* Bergh, 1898, holotype: One specimen 11 mm preserved length, Isla de Pajargo (probably Isla de Pájaros north of Chile), collected by Plate, deposited at the Zoological Museum Berlin (ZMB), Museum number ZMB 50748.

## RESULTS

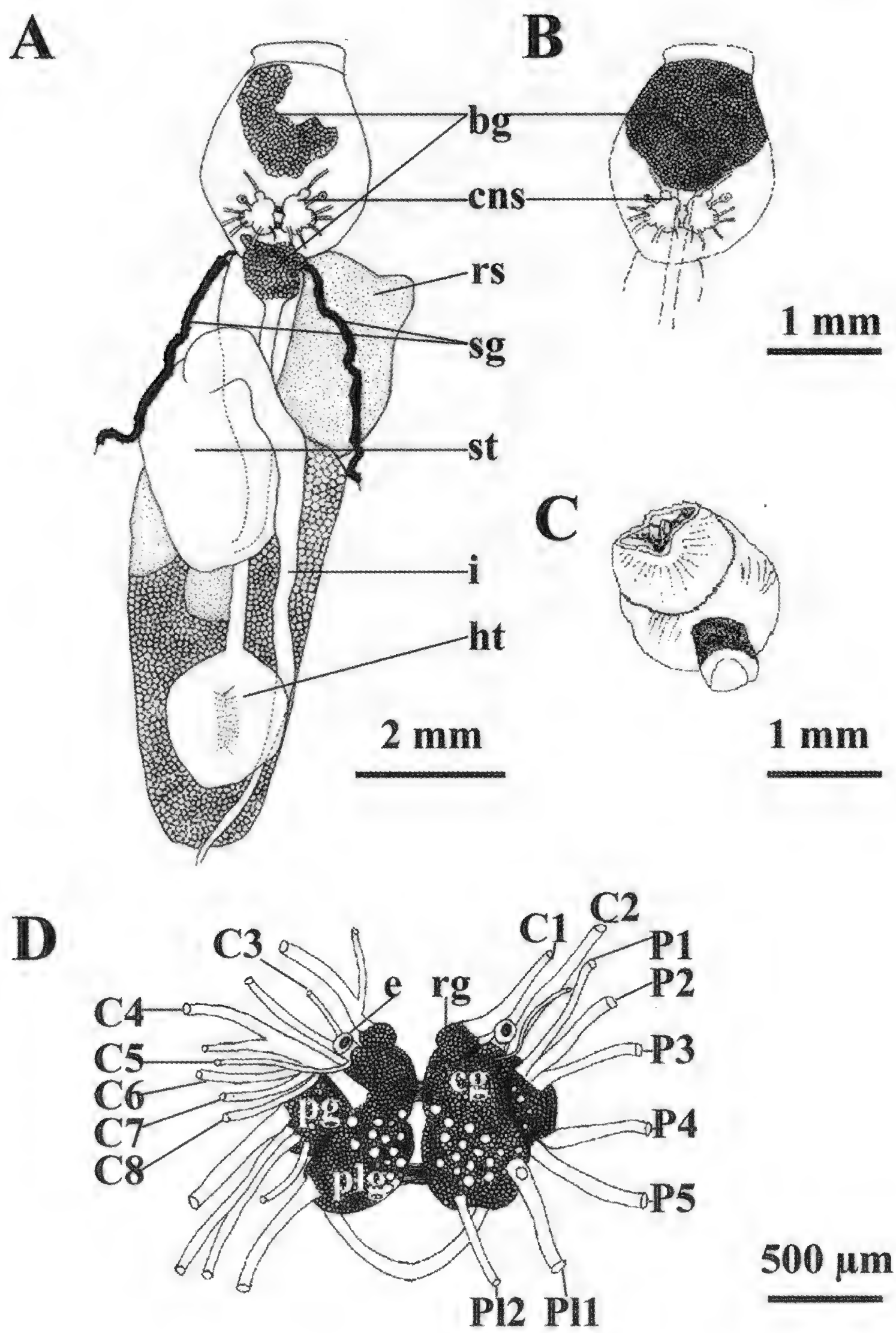
### EXTERNAL MORPHOLOGY (FIGURES 2, 3, 5)

Live specimens are orange in colour (Label information on the specimens from La Portada, Antofagasta SSUC-2607). The ground colour of preserved specimens is a uniform white to beige with remnants of orange pigmentation. The rhinophores and gills are hyaline white. The body is elevated, oval (Figs. 2A, 3A) and slightly convex (Fig. 3B). The whole notum is finely covered by scattered rounded caryophyllidia, which are largest at the mid-line of the body and smaller at the margin of the mantle (Fig. 2A, 3A). The caryophyllidia are small, with a diameter of 20-50 µm, consisting of rounded tubercles, and having spicules around them with mostly broken and contracted cilia at the centre. The notum of the specimens we examined was not well preserved and the caryophyllidia were difficult to see, even with the SEM (Figs. 5A-D). The rhinophores are perfoliate with 7-10 lamellae. The branchial tuft consists of 6 uni-bipinnate gills, which form a circle around the anus at the posterior end of the body (Fig. 3A). The genital aperture is situated on the right side of the first third of the body (Fig. 3B). Ventrally, the head is small with short digitiform oral tentacles. The foot is narrow, with the anterior edge notched at the mid-line and grooved. The notal margin is wider than the foot (Figs. 2B, 3C).



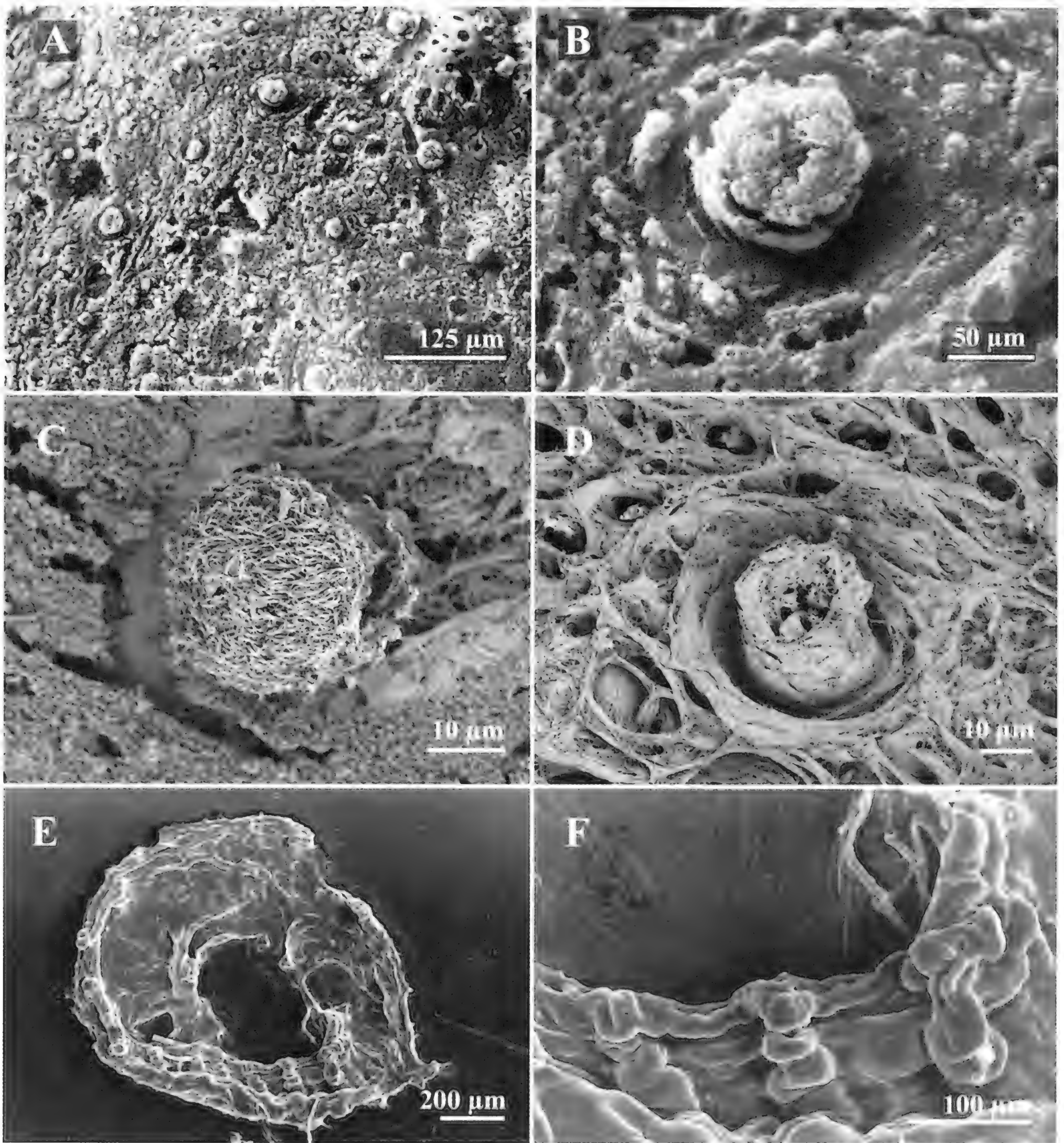


**Figure 3** Specimen of *Baptodoris peruviana* of 11.5 mm (preserved) from Los Molles. A Dorsal view. B Lateral, right side view. C Ventral view.



**Figure 4** A Ground internal anatomy. B Detail of the blood gland. C Buccal bulb. D Central nervous system. Abbreviations: *bg*, blood gland; *C1-C10*, cerebral nerves; *cns*, central nervous system, *cplg*, cerebro-pleural ganglion; *e*, eye; *pg*, pedal ganglion; *ht*, heart; *i*, intestine; *o*, oesophagus; *P1-P5*, pedal nerves; *rg*, rhinophoral ganglion; *rs*, reproductive system; *sg*, salivary gland; *st*, stomach.





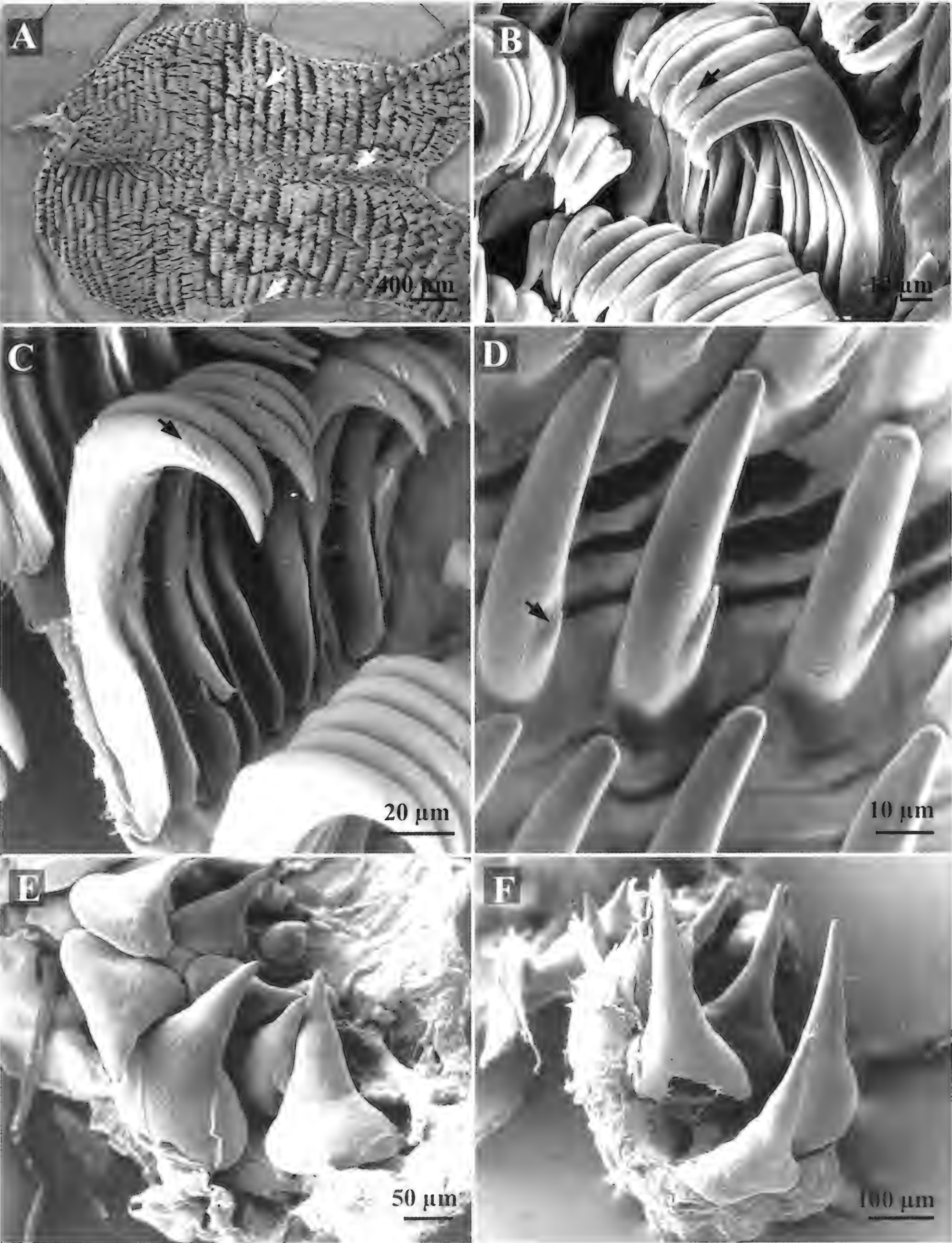
**Figure 5** A Pieces of mantle with caryophyllidia. B, C and D Detail of different caryophyllidia. E Labial disc. F Detail of the labial disc.

#### INTERNAL ANATOMY

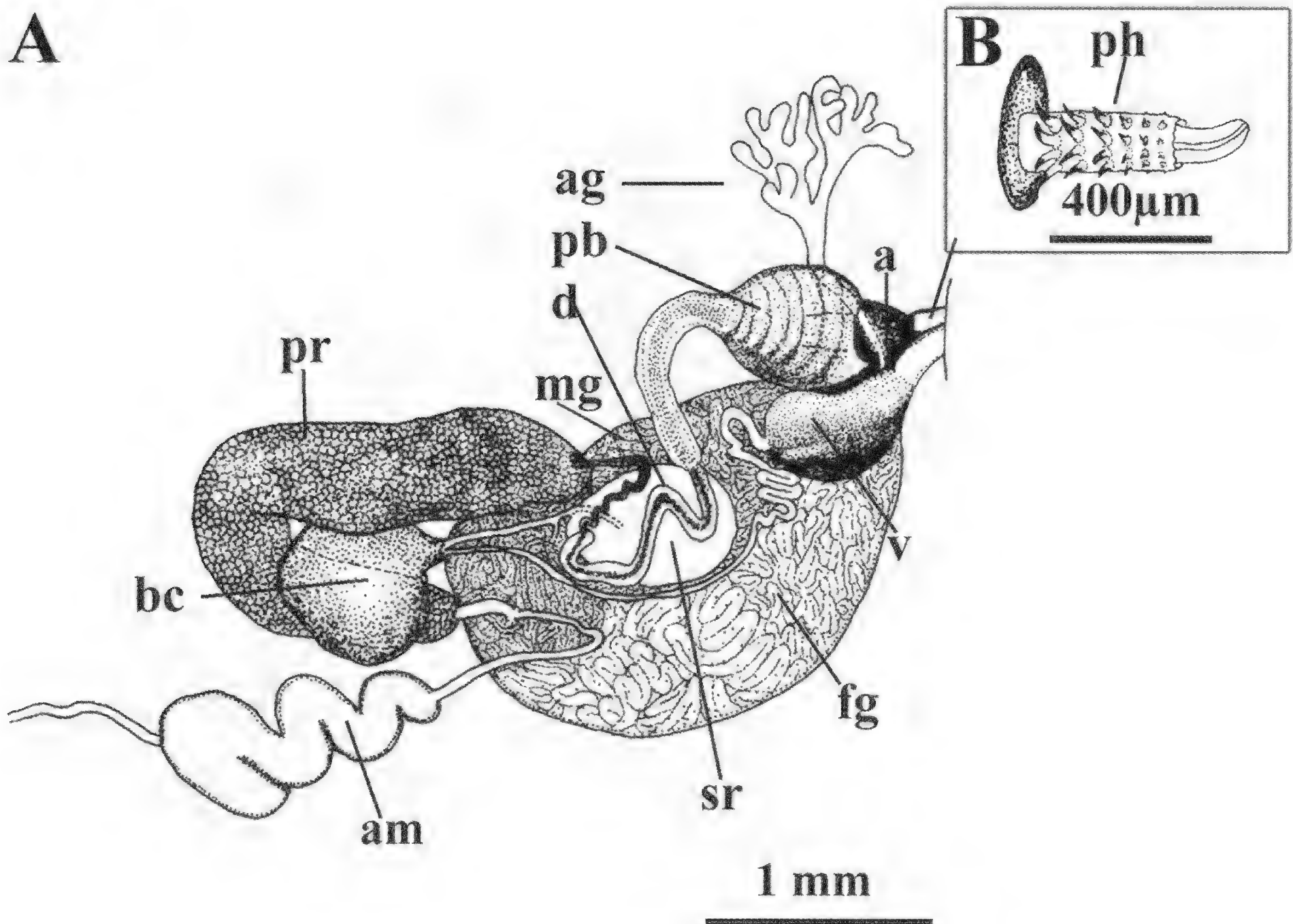
##### *Digestive system* (Figures 4, 5, 6)

The buccal mass is large and muscular (Fig 4A-B). The labial cuticle is smooth and the disc is granulated (Fig 5E-F). Radular formulae of three specimens of 9 mm, 15 mm and 21 mm were 38 x 46.0.46, 31 x 48.0.48 and 36 52.0.52, respectively. The lateral teeth are hamate, having a single cusp with 1-3 denticles on their outer edge, the inner teeth with a single denticle, the middle with 1-2 denticles and the outermost with three (Figs 6A-D). The oesophagus is long and wide, and is connected ventrally to the stomach at the posterior end. The intestine runs along the right side of the body and opens behind the heart. A pair of long and finely granular salivary glands enter to each side of the pharynx in front of the opening to the oesophagus (Fig 4A).





**Figure 6** A Radula, arrows indicate mid, inner and outer lateral teeth. B Detail mid-lateral teeth, arrow showing the denticles on one the tooth. C Detail outer lateral teeth, arrow showing the denticles on one tooth. D Detail inner lateral teeth, arrow showing the denticle on one tooth. E Deferent duct hooks. F Penial hooks.



**Figure 7** A Reproductive system. B Detail of the penis. Abbreviations: a, atrium; ag, accessory gland; am, ampulla; bc, bursa copulatrix; d, deferent duct; fg, female gland; mg, mucous gland; pb, penial bulb; ph, penial hooks; pr, prostate; sr, seminal receptacle; v, vagina.

**Reproductive system (Figures 6E-F, 7):**

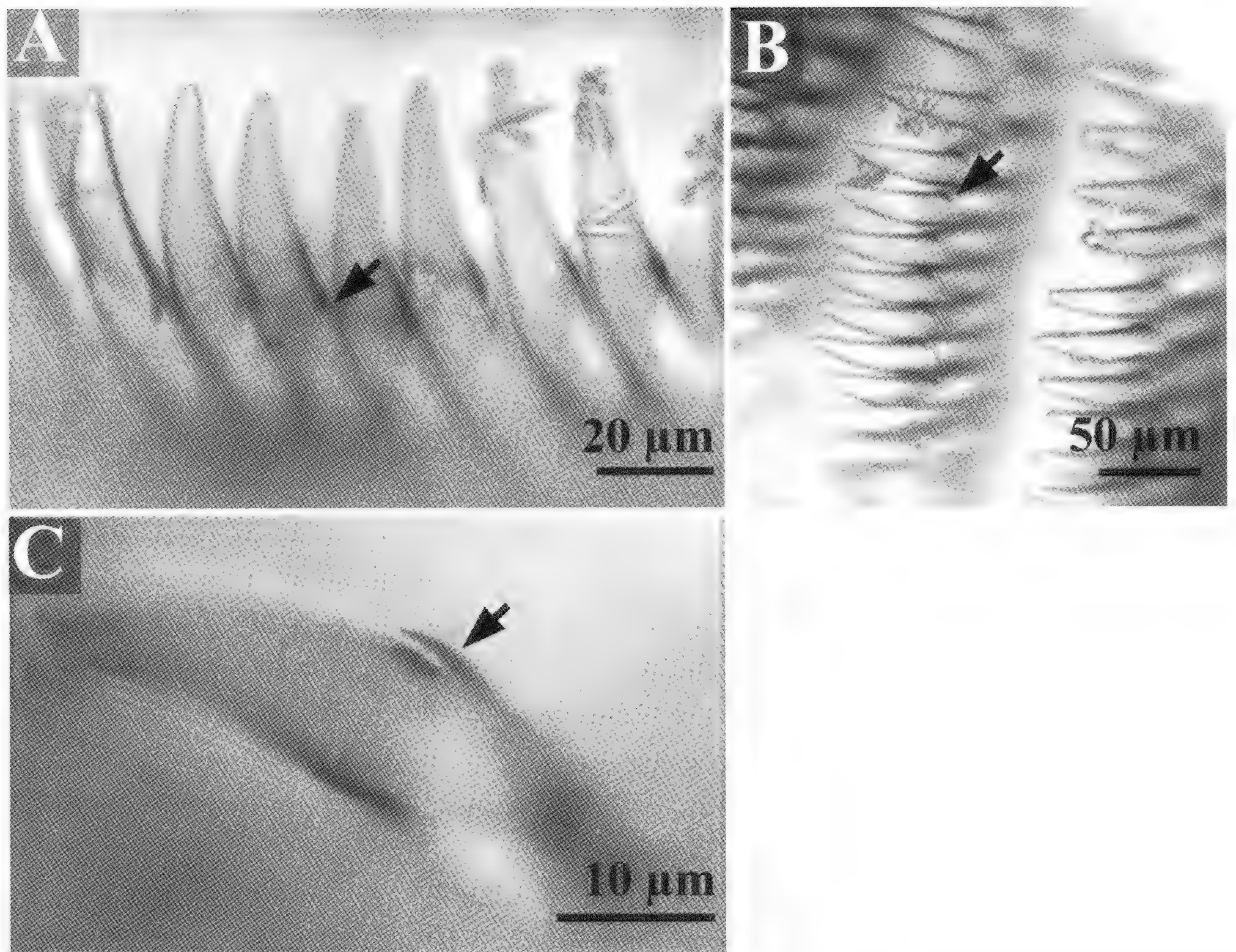
The arrangement of the reproductive organs is triaulic and its description is based on that observed in three specimens of 15 mm, 21 mm and 22 mm (preserved), respectively. The ampulla is long, broad, and convoluted, and at its distal end the ampulla divides into a short oviduct and the prostate (Fig. 7A). The oviduct enters the mucous gland. The prostate is massive and granular and narrows into a convoluted deferent duct. The distal two thirds of the deferent duct have their wall covered with hooks which reach a diameter of 188  $\mu\text{m}$  in one specimen of 21 mm. The penial bulb is bulky. The penis is armed with 6 rows of penial hooks with a diameter up to 170  $\mu\text{m}$  in one specimen of 26 mm (Fig. 6F, 7B). The penial hooks nearest the atrium are smaller than the more internal ones. An accessory gland is present near the upper part of the penial bulb. It runs as a fine and thin duct attached and underneath to the penial bulb and is connected to the common atrium. This gland is tree-shaped, with a mass of digitiform lobes. The atrium, armed with large hooks, reaches a diameter of 286  $\mu\text{m}$  and 400  $\mu\text{m}$  in two specimens of 15 mm and 22 mm, respectively. The female portion of the reproductive system has a long bulky vagina, folded several times, and connected to the large and heart-shaped bursa copulatrix. Leading from the bursa copulatrix is another long duct that connects to the pyriform seminal receptacle and the uterine duct, which enters the female gland. The bursa copulatrix is larger than the seminal receptacle (Fig. 7A). The vagina of one specimen of 22 mm presents small hooks that reach a diameter of 114  $\mu\text{m}$ . Three portions can be recognized in the female gland: the mucous gland is the biggest, with broad and hyaline yellow ducts; while the medium sized portion (the capsule gland, probably) is hyaline cream, with wide ducts; and the smallest (the membrane gland,

TABLE 1  
Comparison of the species of the genus *Baptodoris*.

	<i>B. cinnabarina</i> Bergh, 1884	<i>B. mimetica</i> Gosliner, 1991	<i>B. phinei</i> Valdés, 2001	<i>Baptodoris peruviana</i> (d'Orbigny, 1837)
Length	14-36 mm	Up to 36 mm	21 mm	6-26 mm
Ground colour	Yellow; light orange to dark red with white and brown spots.	Bright lemon yellow with white spots.	Uniformly pale cream	Orange; whitish body with brown markings on the central notum and white margin
Caryophyllidia	Small, diameter 40 µm, short conical base, long spicules and very large, rounded ciliated tubercles.	Minute, diameter 30-50 µm, with a ring of 7-12 calcareous spicules, the centre covered by dense cilia.	Conical, largest diameter over 100 µm, with elongate, ciliated tubercles and 5 spicules around them	Rounded diameter 20-50 µm, tubercles with spicules around them and the centre with cilia.
Rhinophores	Perfoliate, 12-19 lamellae	Perfoliate, 14 lamellae	Perfoliate, 32 lamellae	Perfoliate, 7-10 lamellae
Branchial leaves	6 bipinnate	7-8 bipinnate	5 tripinnate	6 bipinnate
Radular formula	34 x 38.0.38; 41x 53.0.53	38 x 51.0.51	20 x 18.0.18	31-38 x 46-60.0.46-60



	<i>B. cinnabarina</i> Bergh, 1884	<i>B. mimetica</i> Gosliner, 1991	<i>B. phinei</i> Valdés, 2001	<i>Baptodoris peruviana</i> (d'Orbigny, 1837)
Teeth	Narrow and hamate, lateral teeth with a simple denticle, the two outermost have 8-10 small denticles.	Broad and hamate, the outermost with denticles.	Hamate, inner lateral teeth with one denticle, outermost with several denticles.	Hamate with 1-3 denticles, inner lateral teeth with one denticle, middle with 1-2 denticles, outermost with 2-3 denticles.
Penis	Armed with 8 rows of large penial hooks	Armed with 4 rows of minute chitinous hooks	Unarmed	Armed with 6 rows of different sized hooks
Accessory gland	Granular	Large and lobate	Simple	Digitiform tree shaped
Blood gland	Divided in two parts	Undivided ( <i>Gosliner, pers. comm.</i> ).	Undivided	Diveded in two parts or undivided
Geographic distribution	Western Mediterranean	California	Coral Sea  close to  New Caledonia	San Lorenzo, Peru-Valparaíso, Chile.
References	Schmekel & Portmann (1982); Ballesteros & Valdés (1999); Perrone (1985); Valdés & Gosliner (2001)	Gosliner (1991)	Valdés (2001)	D'Orbigny (1837); Bergh (1898); Schrödl (1996a; 2003); present study



**Figure 8** Radular teeth of the holotype of *Platydorís punctatella* Bergh, 1898 (Light microscope). A mid-lateral teeth. B Two rows of lateral teeth. C detail of one denticle in a mid-lateral tooth. Arrows shows the denticles on the teeth.

probably) portion has fine brown ducts. The terminology of the nidamental glands used here follows that of Klussmann-Kolb (2001a, b).

#### **Central nervous system (Figure 4A, B, D)**

It is placed at the posterior end of the pharynx, at the beginning of the oesophagus. The cerebral and pleural ganglia are fused together in the cerebro-pleural ganglia and are separated from the pedal ganglia. On the right side, there are three cerebral nerves leading from the anterior region of the cerebro-pleural ganglion: C1, the rhinophoral nerve; C2, the oral nerve and C3 is the optical nerve; as well as two nerves (C9 and C10) leading from the posterior region of this ganglion. On the left side, there are eight nerves leading from the left cerebro-pleural ganglion, but it was impossible to ascertain the course of C4-C8. The rhinophoral and optical ganglia are distinct from the cerebro-pleural ones. Leaving the pedal ganglia, five pedal nerves can be recognized on the right (P1, P2, P3, P4 and P5), while only four pedal nerves are visible on the left side (Fig. 4D).

#### **Circulatory system (Figure 4A, B)**

The blood gland is thin, large and almost translucent. This structure can be undivided or divided in two parts. When it is undivided, is situated over the buccal bulb before the central nervous system. When it is divided in two parts, one of them is situated over the oesophagus, after the central nervous system. The blood gland connects to the large heart through the aorta.

## GEOGRAPHIC RANGE

This species has been collected from the coast of San Lorenzo (Perú) to Valparaíso (Chile). Its record from the Galápagos Islands is considered dubious and not considered here. Geographic range of this species is shown in the Figure 1.

## DISCUSSION

According to Valdés & Gosliner (2001) the diagnosis of *Baptodoris* is: "Body flexible; dorsum covered with very small caryophyllidia; rhinophoral and branchial sheaths low; labial cuticle smooth; inner and mid-lateral radular teeth hamate and outermost teeth multidenticulate; prostate massive, with two different portions; penis armed with hooks; atrium armed with very large hooks; accessory gland lobate, without a spine". Following this diagnosis, we can conclude that our material belongs within the genus *Baptodoris*.

According to Garavoy *et al.* (1999), the genera *Gargamella* and *Platydoris* are most closely related genera to *Baptodoris*. Thus, the only known species of *Gargamella* from Chilean coasts, *G. immaculata* Bergh 1894 is characterized by a convex shape of the body, large caryophyllidia, hamate teeth without denticles and a small lobate accessory gland.

Regarding the genus *Platydoris*, the only species recorded in Chile is *P. punctatella* Bergh, 1898. However, Dorgan *et al.* (2002) remove it from *Platydoris* due to its less depressed body. Nevertheless, Schrödl (2003) disagrees with this opinion as well as considers *P. punctatella* a junior synonym of the d'Orbigny's species (1837) *Doris peruviana* on the basis of the external appearance. He argues that the less depressed body could indicate a basal position within the clade and agrees with Dorgan's *et al.* hypothesis (2002) that species of *Platydoris* arose from cooler waters and expanded from there to the tropics. Nevertheless, a detailed study of the radular teeth of the *P. punctatella*'s holotype examined here shows that the teeth are provided of denticles, one denticle on the inner and mid-lateral teeth and two on some of the outer teeth (Fig. 8A-C). Unfortunately, the only structure of this species that remains available is the radula (the rest of the structures are no longer present), and the holotype of *Doris peruviana* has been untraceable at the Natural History Museum of London (Ángel Valdés, *pers. comm.*) and the Muséum Nationale d'Histoire Naturelle of Paris (Virginie Héros, *pers. comm.*).

The main difference from the comparison between the material of Schrödl (1996a, 2003) and ours is in the coloration of the body, which is whitish with brown markings on the central notum and a white margin in the former and uniformly orange in our specimens. However, this could be due to the range variability of the coloration within this species. Coloration variability has been described by Schrödl (2003) in *Gargamella immaculata* and *Diaulula variolata* (d'Orbigny, 1837). In addition, Schrödl, (2003) mentions only tubercles on the notum in the description of the specimens from Pucasana, Peru. Our SEM observations of the notum show the small caryophillydia in specimens from different localities. Moreover, a branched accesory gland in the reproductive system is not known for any *Baptodoris*, *Platydoris* and *Gargamella* species.

Dorgan *et al.* (2002) described five species of *Platydoris* with denticles on the outermost radular teeth only: *P. macfarlandi* Hanna, 1951, *P. pulchra* Eliot, 1903, *P. sanguinea* Bergh, 1905, *P. cinereobranchiata* Dorgan, Valdés & Gosliner, 2002 and *P. scabra* (Cuvier, 1804). Our specimens have denticles on its inner, mid and outermost radular teeth. We consider this apomorphic character of having all teeth provided with denti-



cles is regarded as separating the genera *Baptodoris* and *Platydoris*. Although, Bergh (1884) did not described radular teeth with denticles for *Baptodoris cinnabarina*, the type species of *Baptodoris*, a later study of this species by Ballesteros & Valdés (1999) described radular teeth with denticles, while the outermost teeth are pectinate. Even if such pectinate teeth are not present in our material, all the above evidence led us to conclude that the present material, as well as *Platydoris punctatella* belongs to the same species, and consequently to the d'Orbigny's *Doris peruviana*. Moreover, the detailed study of the external morphology and internal anatomy has permitted us to demonstrate that this species should be transferred to the genus *Baptodoris*, being renamed as *B. peruviana comb. nov.* A comparison between this species and the remaining well known species of the *Baptodoris* is presented in Table 1. It does not include species assigned to this genus, like *B. tuberculata* Bergh, 1888; *Aporodoris rubra* Bergh, 1905 (considered by Ortea *et al.* [1982] to belong to *Baptodoris*), and *B. fongosa* Risbec, 1928, since their descriptions are poor. Ballesteros & Valdés (1999) suggested that these species should be re-examined to obtain more detailed descriptions of their morphology and internal anatomy. The generic placement of *Baptodoris perezi* Llera & Ortea in Ortea, Pérez & Llera, 1982, is also doubtful, because this species has caryophyllidia only at the mantle margin, radular teeth without denticles and no accessory gland (Ortea, Perez & Llera, 1982; Cervera, García Luque & Ortea, 1986; Perrone, 1986). This species probably belongs to a different genus of the Discodorididae Bergh, 1891 (Ballesteros & Valdés, 1999). Recently Dorgan *et al.* (2002) include *Platydoris maculata* Bouchet, 1977 as a junior synonym of *B. cinnabarina*, and in the same study these authors argue that the reproductive system of *Platydoris stomascuta* is similar to other species of *Baptodoris* and must be included into this genus. However, Bouchet (1977) did not described radular teeth with denticles in this species. For this reason, it is not considered a true *Baptodoris* species in our study. It is necessary to re-examine these species before removing them from *Platydoris*.

According to Garavoy *et al.* (1999), the penial hooks in *Platydoris* and *Baptodoris* are smaller than 70 µm in diameter, but in our material they reach a diameter of 170 µm. Moreover, the accessory gland of *Baptodoris peruviana* opens into the atrium, very close to the penial bulb and not in the vaginal duct like in the remaining species of the genus. Comparison of data about the central nervous system and the blood gland between the species of *Baptodoris* are presented in Table 1.

*Baptodoris phinei* has been included within the Table1, although Valdés (2001) suggests that this species is provisionally placed in this genus, because it lacks penial hooks and eyes which are present in the remaining species of the genus. Moreover, we can add further differences: *B. phinei* has considerably more lamellae on the rhinophores, the gills are tripinnate and the number of radular rows and the number of teeth of the middle row is smaller than in the other species of the genus.

Because the holotype of *Baptodoris peruviana* is untraceable and the identity of this species is problematic, we propose the designation of a neotype based on articles 75.3.2 and 75.3.3 of the International Code of Zoological Nomenclature. We have selected as neotype of *B. peruviana* an undissected specimen from Iquique (Chile). The holotype of *P. punctatella* is poorly preserved, the specimen is eviscerate and only the radula could be examined, and the type locality of this species (Isla Pájaros, Chile) is farther away from the type locality of *B. peruviana* than Iquique. Therefore, we decided to select the specimen from Iquique as the neotype of *B. peruviana*, so *P. punctatella* remains as a subjective synonym of *B. peruviana*.

## ACKNOWLEDGEMENTS

The authors would like to thank Mr. Patricio Zabala, curator of SSUC, for allowing us access to the studied material. A debt of gratitude is owed to Virginie Héros (Musée Nationale d'Histoire Naturelle at Paris), Tyjuana Nickens (U.S. National Museum) and Frank Koehler (Museum für Naturkunde, Berlin) for the supplied information on *Doris peruviana*'s holotype. Our acknowledgement to Drs. Ángel Valdés and Terry Gosliner their comments about some aspects of the manuscript. Comments of an anonymous referee improved very much the last version of the manuscript. Many thanks are also due to Dr Elisabeth Pierson, Mr Huub Geurts and Mr Gideon Bevelander their assistance in several technical aspects during the elaboration of the manuscript, as well as to Mr Jan Klerkx the improvement of the language). The first author want to express her most deep gratitude to Profs. Dietrich Hofmann (University of Bochum, Germany) and Gerard van der Velde (University of Nijmegen, The Netherlands) the access to the facilities of their laboratories, as well as to their review of the manuscript.

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# ESTIMATING THE SPECIES RICHNESS AND COMPOSITION OF LAND MOLLUSC COMMUNITIES: PROBLEMS, CONSEQUENCES AND PRACTICAL ADVICE

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*Abstract* Inventories of land molluscs based on samples are liable to biased sampling error, because species that are present may be missed. Such errors may give a false impression of the degree of difference between faunas from similar sites, and they are confounded with genuine heterogeneity, which has considerable ecological and conservation significance. The statistical properties of such errors are examined briefly in the context of sample size and the frequency distribution of species. The effectiveness of different sampling strategies is assessed, taking account of the different life cycles and behaviour of various mollusc species. Taking random quadrats alone is not an efficient method for inventory; a combination of visual search and extraction from litter and soil is required. A set of practical guidelines is given, and the importance of good inventories, especially in oligotrophic habitats, is underlined.

*Key words* Land molluscs, species richness, sampling methods

## INTRODUCTION

Inventories of species in sites of varying size are basic both to ecological and biogeographical analyses, and to conservation planning. Such inventories are usually based on samples or collections rather than on complete censuses, and they are subject to error. This error is biased; species may be missed.

There are sophisticated statistical methods for estimating this bias, and on how to allow for it when making comparisons among sites or regions (Colwell and Coddington, 1994; Gotelli and Colwell, 2001; Colwell, 2001). There are also techniques for minimizing it by determining the appropriate sampling technique and effort. The practical problems of reducing it to an acceptable minimum, however, depend on the character of the particular group of animals or plants being studied.

In the context of land molluscs, this problem has long been recognised. Boycott (1921), writing about the molluscs of a single English parish commented:

“ Especially as regards absence or paucity, the evidence of single examinations is of little moment.... even with repeated search, one has, no doubt, to be a little cautious.... I have been a good deal impressed by the necessity of going over the same ground again and again under different conditions of climate and season.”

Despite this observation, many accounts of land mollusc species richness and composition rely on single-visit surveys, admittedly using more sophisticated techniques than those of Boycott. Studies vary in the sampling methods used, often because they are intended to give estimates of density or true relative abundance, but also because some workers have relied on the “objectivity” of randomised samples to make results comparable. In well-worked areas, such as N. Europe, the adequacy of inventories can often be checked against a substantial body of earlier work. In other areas, including some of high conservation value, this independent check is not available, and repeat samples on any scale are an unaffordable luxury. In particular cases (De Winter and Gittenberger, 1998; Schilthuizen and Rutjes, 2001) sampling error may be manifest, recognised and considered; usually, it is not. Its significance was recognised by Emberton, Pearce and Randalana (1996), who provided the only detailed study of the efficiency of different

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sampling techniques in terms both of sampling error and processing time.

In this paper, we give examples of the potential effects of sampling error, and we examine some of the factors affecting the quality of inventories of land molluscs, especially at the level of "sites": small areas ( $< 1\text{km}^2$ ) of apparently uniform habitat. We consider the statistical background to sampling, and the practical problems and issues arising from the biology of land molluscs. Taking note of the preference for random sampling shown in many studies (essential where density estimates are required) we discuss its appropriateness for inventory work. We use our analyses to make suggestions about suitable sampling protocols where a reliable inventory is the main aim, and we point out some issues that can be resolved when inventories are complete, or nearly so. While paying some attention to statistical methods of compensating for error, we concentrate on ways of minimizing it; species composition has at least as much significance as richness *per se* in most molluscan studies, and is far less amenable to statistical inference. Our examples are mainly, but not exclusively, European, reflecting our own field experience.

### POTENTIAL EFFECTS OF SAMPLING ERROR IN MOLLUSCAN INVENTORY WORK

We use the term sampling error in a very specific sense: the failure to find a species in a quadrat, site or area when it is actually present. In this sense, sampling error is likely to be most important at intermediate scales: those large enough to prohibit a complete census, but small in the sense that an inventory is not based on a multitude of samples scattered over it. Although it is possible to miss species when removing an entire quadrat, and searching it exhaustively, the errors are likely to be small. At the scale of regional or national atlases based on tetrads or hectads, or even on a less systematic accumulation of localised records, failures tend to balance out; inventories for particular sites or squares may be incomplete, but the large number of sites involved means that nearly all species in the larger area are found (Cameron, 2002).

It is, however, at these intermediate scales that accurate inventories are most useful, for investigating syntopic diversity, for looking at small-scale differentiation in species composition, and in conservation planning. Table 1 shows the results of a number of recent studies of land mollusc diversity. In each case, it is possible to establish both the mean level of richness in sites of a particular type, and the degree of differentiation among such sites. It can be seen that the degree of differentiation, measured by Whittaker's Index,  $S/\alpha$ , where  $S$  = the total number of species recorded for the type, and  $\alpha$  = the mean number of species per site, varies considerably between studies. Other measures of difference or affinity would give essentially similar results (Koleff, Gaston and Lennon, 2003).

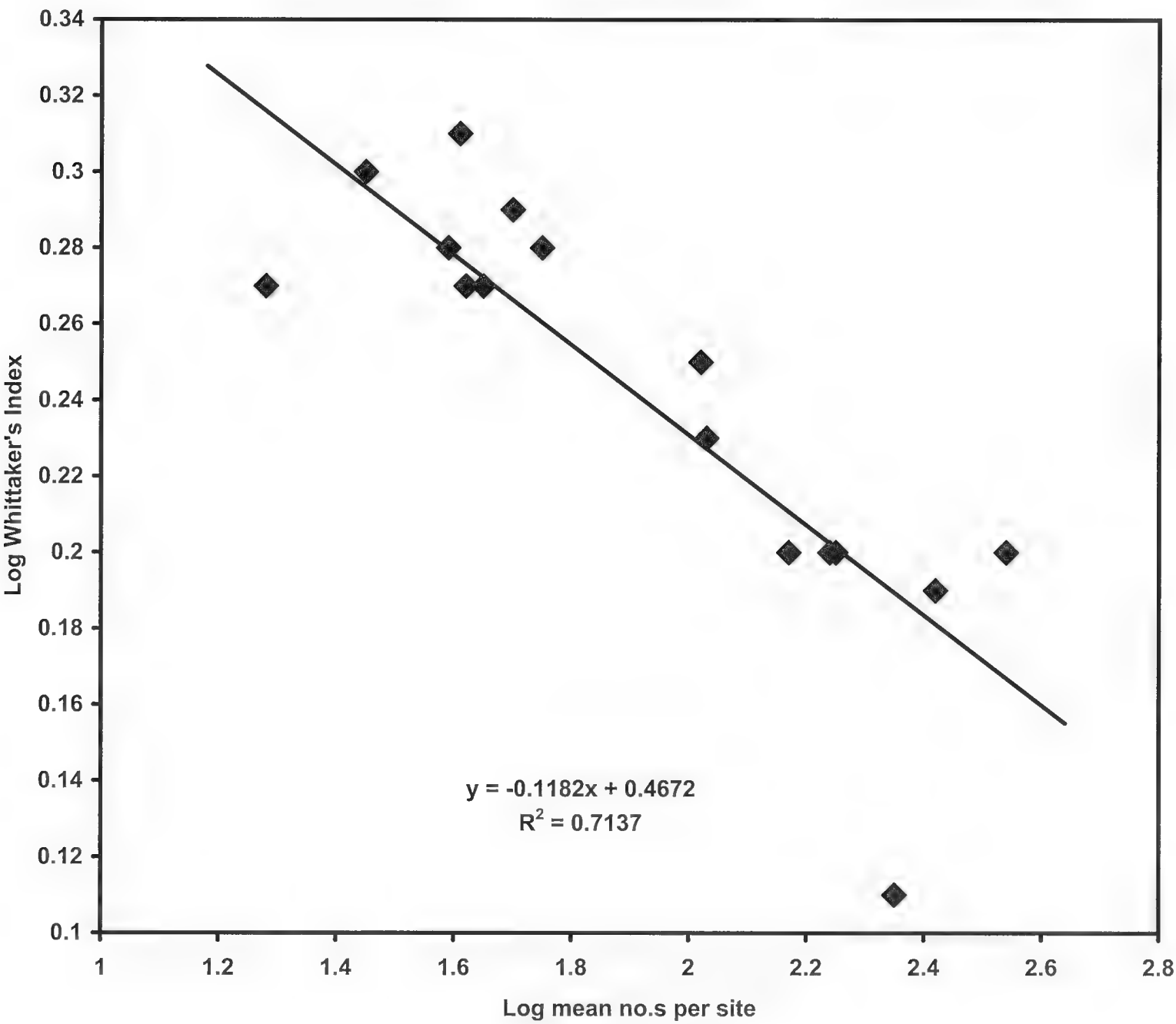
At face value, these differences might have considerable biological implications. However, the table also shows that the value of the index is strongly correlated with the average size of the samples taken ( $R^2 = 0.94$ ,  $P < 0.001$ , for the log/log regression of index on mean sample size). In the case of both Sabah and Cameroon, the mean sample size is smaller than the total number of species recorded in the surveys, so it is not possible for all species to be recorded at each site. Clearly, sampling error can account for much of the differences in heterogeneity amongst studies.

The studies above span a wide range of environments, and they are a selected set. The same phenomenon, however, can occur within single studies (Figure 1). Before dismissing all such variation among similar sites as sampling error, however, it should be noted that there is good evidence for real differences between habitats in local heterogeneity, albeit at the much smaller scale of  $1\text{ m}^2$  quadrats (Schmid, 1966. Figure

TABLE 1

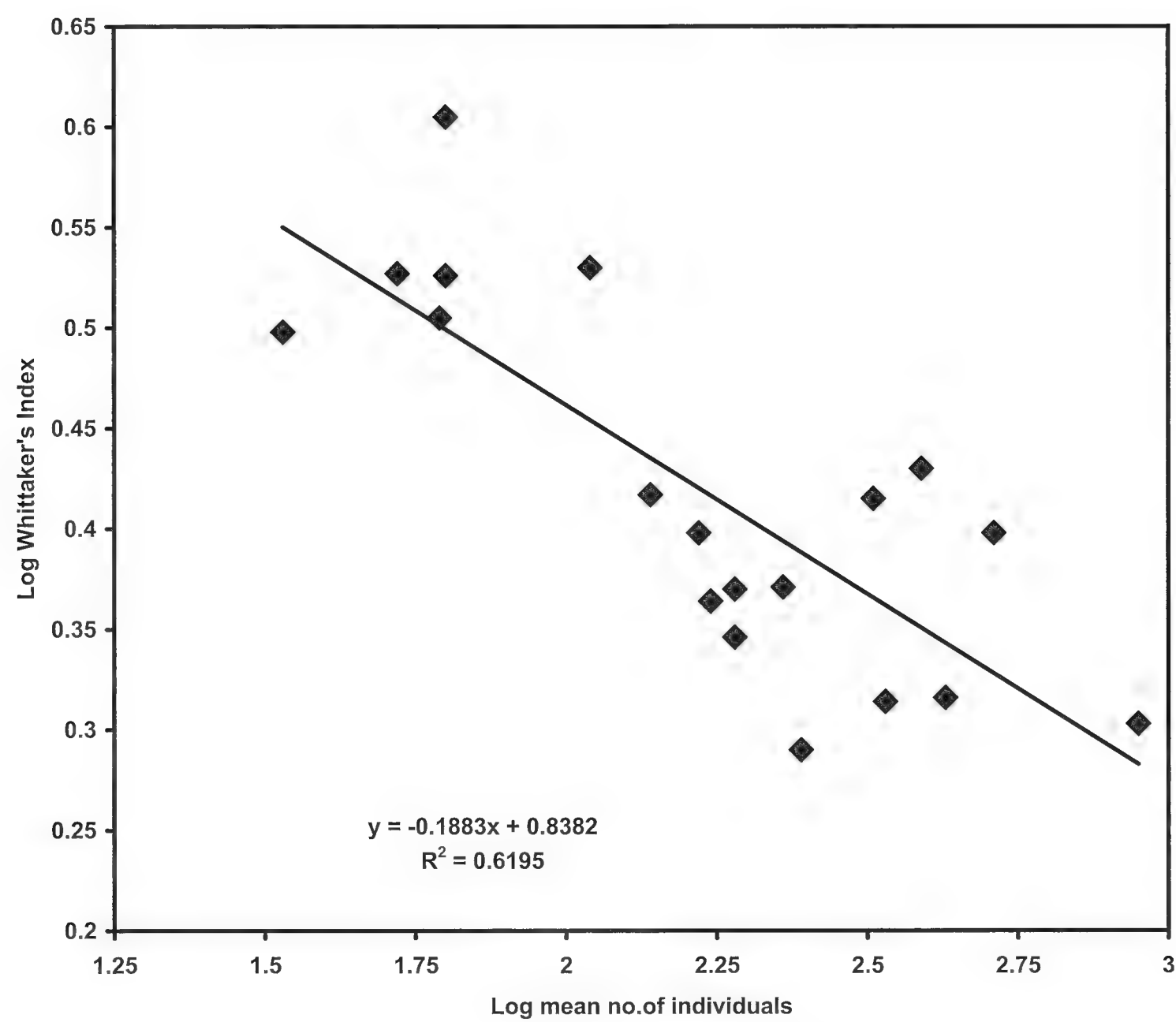
Heterogeneity in snail faunas among sites in relation to sample size in ten studies using comparable techniques. Each study refers to plots sampled in the same general habitat-type in a confined area (less than 300 km<sup>2</sup>). The studies are arranged in descending order for Whittaker's Index. S, total number of species recorded;  $\alpha$ , mean number of species per site; I, Whittaker's Index; No./ Site, mean number of individuals found per site. Data for Cameroon refer only to standard areas, not to boulders; Kenya 1 refers to pine plantations and Kenya 2 to indigenous forests; Sweden 1 refers to Oak forests, and Sweden 2 to dry meadow woods.

Location	Sites	S	$\alpha$	I	No./ Site	Source
Sabah	36	52	6	8.5	11	Schilthuizen and Rutjes, 2001
Cameroon	24	95	27	3.6	79	de Winter and Gittenberger, 1998
Kenya 1	8	34	13	2.5	136	Tattersfield, Seddon & Lange, 2001
Kenya 2	27	50	23	2.1	138	Tattersfield, 1996
Sweden 1	10	15	7	2.0	129	Wäreborn, 1969
Poland 1	17	42	24	1.7	276	Cameron and Pokrysko, 2004
Sweden 2	12	28	17	1.7	367	Wäreborn, 1969
Poland 2	8	26	17	1.5	236	Pokryszko and Cameron, unpub.
Crete	14	21	15	1.4	c.500	Cameron <i>et.al.</i> , 2003
England	8	40	31	1.3	700	Cameron and Pokryszko, unpub.

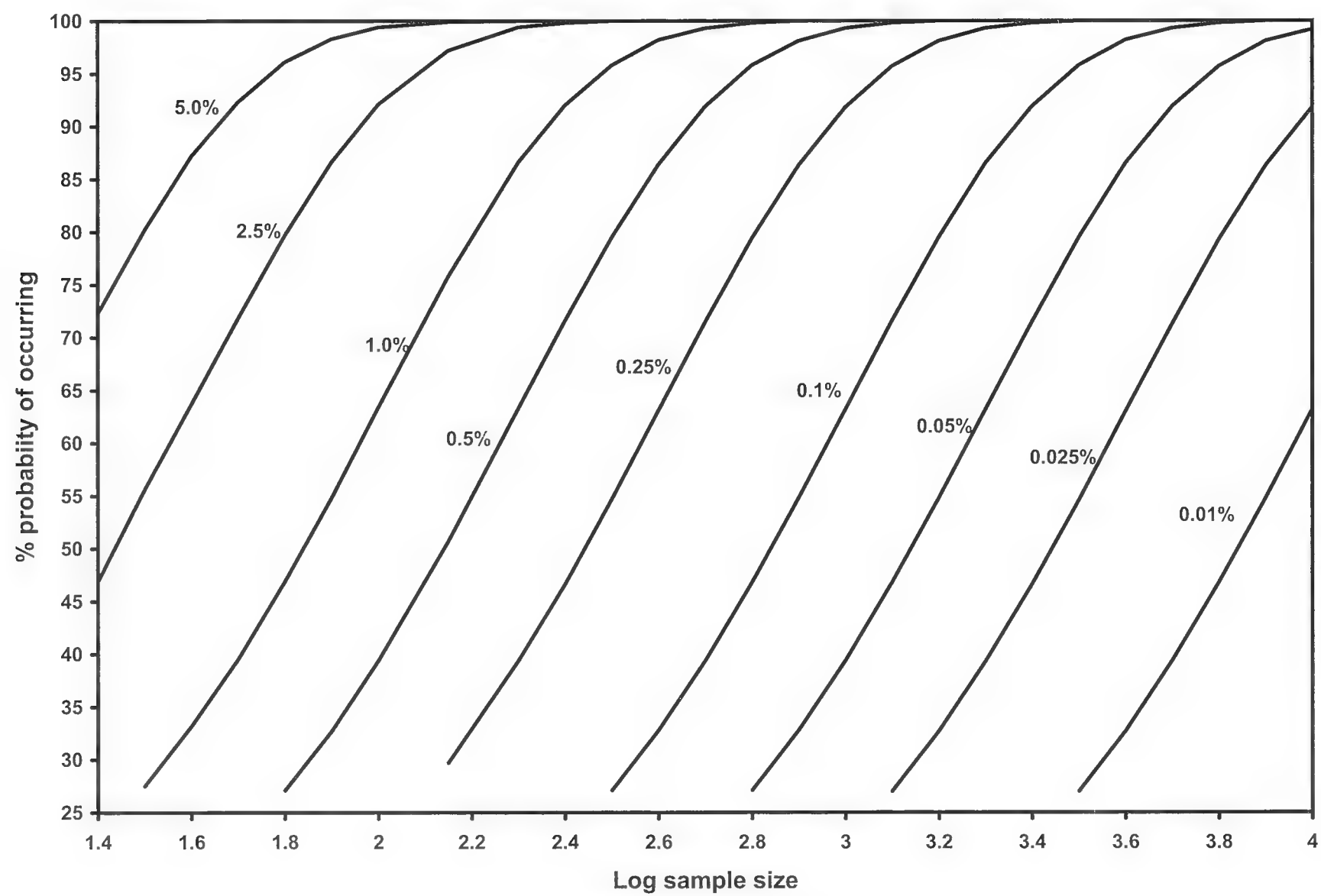


**Figure 1** The logarithmic relationship between Whittaker's Index and mean sample size for 16 sets of four adjacent plots sampled on Mt. Kenya by Tattersfield, Warui, Seddon & Kiringe (2001). The regression is highly significant,  $P < 0.001$ .





**Figure 2** The logarithmic relationship between Whittaker's Index and mean number of individuals per 1 m<sup>2</sup> quadrat for 19 different habitats on the Spitzberg, Tübingen (Schmid, 1966). The regression is highly significant ( $P < 0.001$ ). Since these data represent censuses at quadrat level, the greater heterogeneity of poor habitats is genuine, and not a sampling artifact.



**Figure 3** A nomogram showing the probabilities (%) of finding species occurring at specified frequencies (%) as a function of sample size.

2). Since we are dealing here with census data (the comparison is between completely extracted quadrats), it is the case that habitats with lower overall densities are more heterogeneous. Inspection of Schmid's data shows that these are the more acid and species-poor habitats in his set. Where site totals are based on samples, the effects of error and real heterogeneity are often confounded, as in Białowieża Forest, where acid, species-poor habitats showed greater heterogeneity but also had smaller samples (Cameron and Pokryszko, 2004). Genuine heterogeneity in composition among sites independent of environmental variation is potentially important; it relates to the idea that ecologically equivalent species can co-exist in the same habitat through shifting metapopulation structures (Hubbell, 2001). It also has consequences for decisions on the size and siting of protected areas.

### THE STATISTICAL CONTEXT

While notional, "ideal" patterns of distribution and frequency do not occur in most natural communities, their statistical properties set a minimum standard for sampling. Thus, when an unbiased sample is taken from a community of co-existing species where individuals are distributed at random, the chances of finding or missing any particular species are determined by the absolute size of the sample and the relative frequency of the species concerned (Figure 3). A 90% chance of finding a species can also be expressed by saying that in 9 out of 10 samples of the appropriate size, the species will be found. The rarer the species, relative to the whole, the larger will be the sample needed to reach a given probability of detection.

The mean frequency of species in a community will fall as the community gets richer. Larger samples are thus required to achieve the same level of completeness. Even amongst communities with the same number of species, the frequency distribution of species within each will affect the size of sample required to reach a given level of completeness. The more equitable the frequency distribution, the smaller the sample needed.

There is a large literature on frequency distributions and their interpretation, reviewed by Southwood and Henderson (2000). Natural distributions are far from even; typically there are a few abundant species, and a long tail of rare species. Of those distributions actually observed, the most even is that generated by the "Broken Stick" model of MacArthur (Southwood and Henderson, 2000); examples of the distribution produced by this model is shown alongside actual distributions in Figures 4 and 5 (see below). Very rare species are few in number; other distributions generate many more species represented by very few individuals. It thus represents the most optimistic pattern of distribution one can expect in terms of the sample size required to achieve a given level of accuracy. Table 2 shows the expected frequency of the rarest species on this model for communities varying in species richness. Taken with Figure 3, it can be seen that, for example, a sample of 2000 or more individuals is required to have a better than 90% chance of finding the rarest species in a community holding around 30 species. With such a frequency distribution, however, having the same chance of finding the second rarest species requires only about half that number of individuals.

Figures 4, 5 and 6 present contrasting cases using real data. In Figure 4, a sample of c.1200 individuals yields a convex frequency distribution closely resembling the Broken Stick, and the sample appears to be adequate (smaller replicates confirm this, see below). The two least frequent species are each represented by 5 individuals. In Figure 5, a much richer fauna is represented. On other evidence, the site holds at least 80 species, but only 52 species and only 353 individuals were recovered by standard sampling (Schilthuizen and Rutjes, 2001). Sampling was particularly difficult; 23 species were represented by

TABLE 2  
Percentage frequency of the rarest species in communities of varying species richness, as expected from the Broken Stick model of MacArthur (see text).

No. of Species	% Frequency		No. of Species	% Frequency
12	0.69		40	0.063
16	0.39		44	0.052
20	0.25		48	0.043
24	0.17		52	0.037
28	0.13		60	0.028
32	0.098		80	0.016
36	0.077		100	0.010

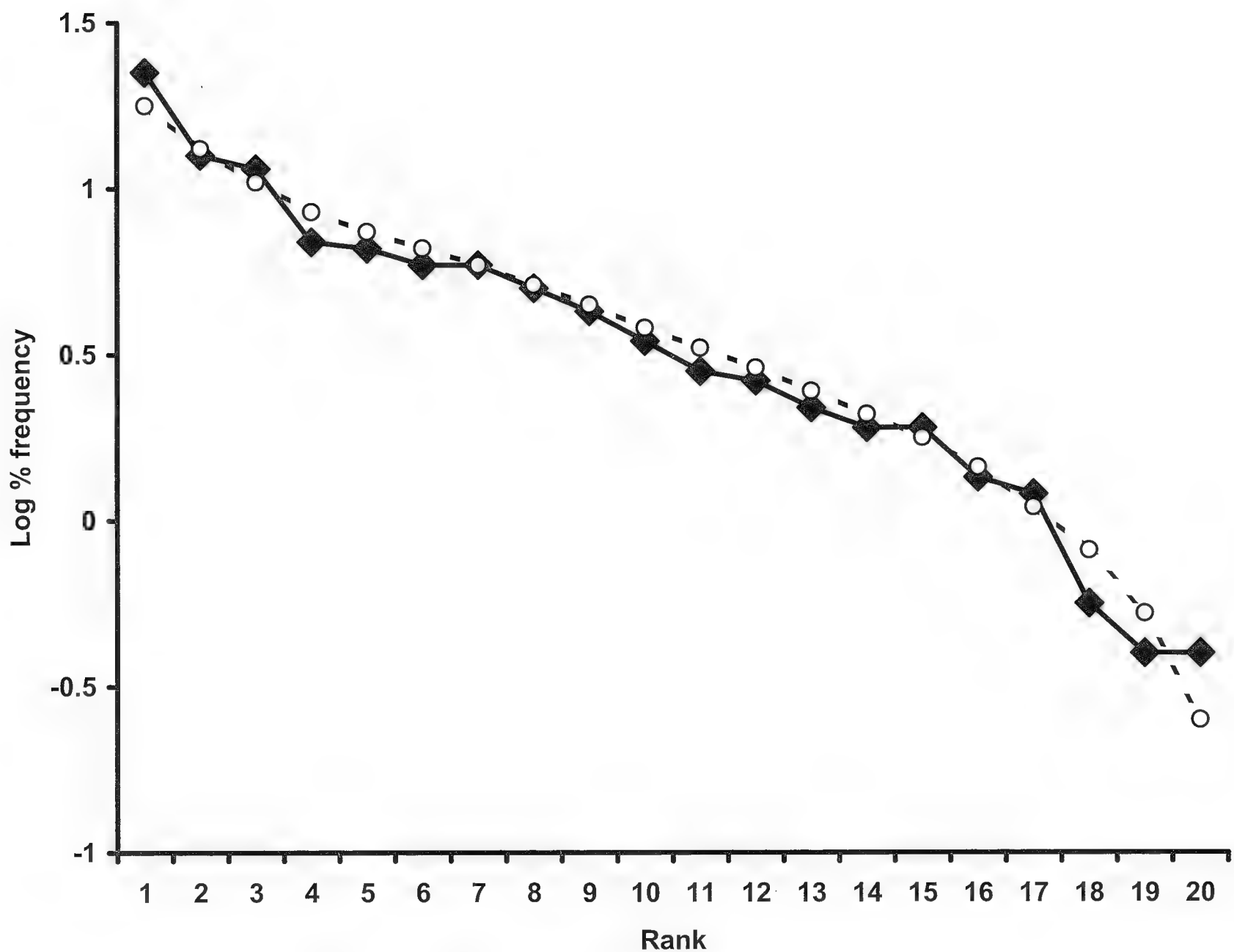


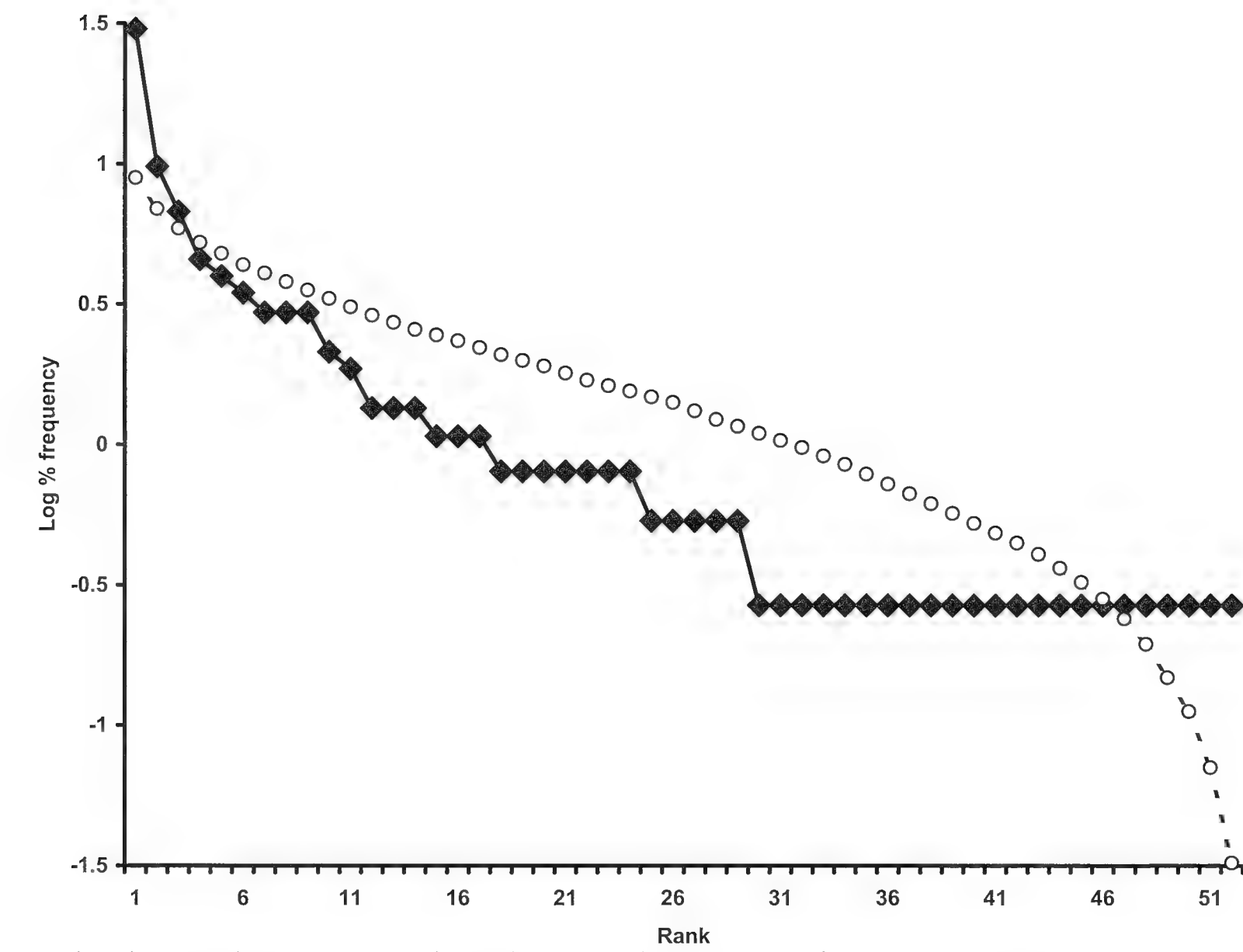
Figure 4 The logarithmic rank-abundance relationship for snail species in Little Matlock Wood, Sheffield (R.A.D. Cameron, unpublished). Diamonds and solid line, the actual data; open circles and dashed line, the pattern expected from the Broken Stick model (see text).

single specimens. On the Broken Stick model, c. 10,000 individuals would be required to have a 90% chance of finding the rarest among 80 species. The figure shows that the frequency distribution is concave, and far less even than that of the Broken Stick, so that an even larger sample would be required in practice.

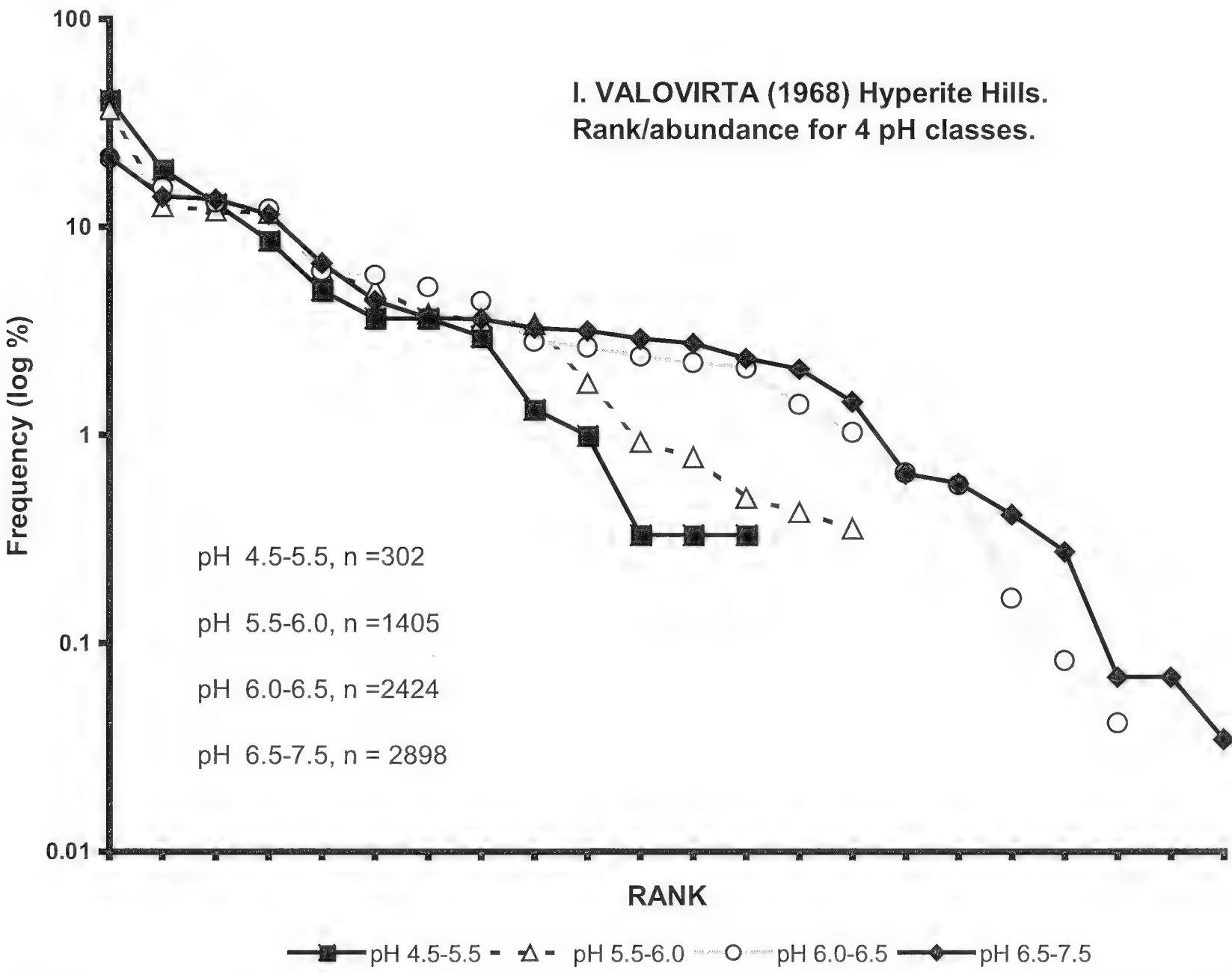
Figure 6 shows data for Finnish forest faunas separated by soil pH classes (Valovirta, 1968). These data get to the heart of the analytical problem; oligotrophic (low pH) sites not only have fewer species, they also have a less even frequency distribution. These data suggest that there is more heterogeneity in oligotrophic sites, but the number of individuals on which the analysis is based is also smaller.

Given appropriate data, there are a variety of statistical techniques available to estimate the level of error in inventories, and for making valid comparisons between





**Figure 5** The logarithmic rank-abundance relationship for snail species in rainforest in Sabah, Malaysian Borneo (Schilthuizen & Rutjes, 2001). Diamonds and solid line, the actual data; open circles and dashed line, the pattern expected from the Broken Stick model based on the 52 species found. The pattern expected on the basis of an estimated total of 80 species would be even more different from that seen (see text).



**Figure 6** The logarithmic rank-abundance relationships for snails in sites from four soil pH classes in forest faunas from Finland (Valovirta, 1968).

TABLE 3

Results of sampling by collection of litter and visual searching in a standard manner in four adjacent 400 m<sup>2</sup> plots in Little Matlock Wood, Sheffield. The data exclude slugs. Means for two and three samples are based on all possible permutations of samples. On average, even single plots retrieve 95% of the known fauna. The aggregated data are used in figure 4.

Sample	Species	Individuals.	Indiv/Species
1	20	326	16.3
2	19	375	19.7
3	20	286	14.3
4	18	265	14.7
Total	20	1252	62.6
Means			
1 sample	19.25	313	16.3
2 samples	19.83	626	31.6
3 samples	20.00	939	46.9

inventories with different errors (Colwell and Coddington, 1994; Gotelli and Colwell, 2001; Colwell, 2001). Gotelli and Colwell (2001) gave a comprehensive review, and we give no details here. The oldest, and best- known technique to estimate error is to construct a species accumulation curve, noting the increase in richness as sampling effort increases. *Post facto* simulations can generate similar curves (Gotelli and Colwell, 2001). If an asymptote is reached, the inventory appears complete and the required sampling effort can be determined. Menez (2001) gave what appears to be the first formal application of this technique to land molluscs; table 3 gives a much less rigorous example. Many authors note that repeat sampling, especially at a different season, can add species to an inventory. Other techniques such as rarefaction, and the use of non-parametric tests were detailed by Gotelli and Colwell (2001) (and see below, page ), and Colwell (2001) provided software to perform the calculations.

There are some pitfalls in interpretation of particular relevance to land molluscs. Some frequency distributions, for example the geometric and the logarithmic, are not asymptotic (Southwood and Henderson, 2000). Some models of community assembly (Hubbell, 2001) also predict no asymptote, at least for large regions, even where there is no environmental heterogeneity. Where species distributions are genuinely patchy on a scale larger than that of the designated sample sites, pooling of samples, even those adjacent to each other, may fail to reach an asymptote, even if all species have, in fact, been recorded in each. Such patchiness will distort estimates of error upwards, in terms both of numbers and frequency of occurrence. Distinguishing between genuine heterogeneity and sampling error requires the reduction of sampling error within individual sites. This can be a serious problem, especially in poor environments where it is very hard to obtain samples containing many individuals (Cameron and Pokryszko, 2004).

Mollusc species and individuals are very rarely, if ever, distributed at random in a site. They are usually aggregated, sometimes to an extreme degree (Cameron, 1982; Sharland, 2001). While it is sometimes the case that many species share aggregations (Nekola and Smith, 1999; Sharland, 2001; Cameron, 2003), different microhabitat requirements give rise to differing local distributions and abundances among species. Thus, a study concerned with distinguishing such requirements, rather than with acquiring a complete site inventory, may well need to be based on a large number of quadrats, each

small enough to contain only a single microhabitat type. Even then, where favourable microhabitats are rare (as a proportion of the site area), a randomised sampling regime based on quadrats may well miss them altogether. For inventory work, this will reduce completeness and exaggerate differences among sites. Within sites, aggregation will increase the variance of estimates of density and frequency.

Throughout this section, we have referred to frequency and frequency distribution as though they were estimates of true values based on unbiased sampling. In practice, different species have differing levels of detectability, dependent on the method of sampling used, and especially on season and weather. Even apparently exhaustive extraction from quadrats may not find all individuals present. In general, apparent frequency of this kind is subject to exactly the same statistical constraints, and conclusions remain the same. Clearly, problems will arise if samples are compared in which the apparent frequency of some species has altered substantially from one occasion to the other, perhaps because of seasonal differences in sampling. On the other hand, sampling methods that selectively increase the probability of encountering rare species, increasing their apparent frequency, present no analytical difficulties for compiling inventories. A sampling regime that equalised the probabilities of finding each species would be the most efficient for inventory work, at least in terms of numbers of individuals to be found.

## SAMPLING METHODS AND THEIR EFFECTIVENESS

### RANDOM QUADRAT (OEKLAND) SAMPLES

In the European context, the most frequently applied sampling technique is the extraction of molluscs from randomly placed quadrats from which litter and soil are removed (Oekland's Method; Oekland, 1929). The quadrats are usually 20 x 20 or 25 x 25 cm, and the total area from which material is removed is usually in the range 1-4 m<sup>2</sup>. In theory, this gives an unbiased estimate of both densities and occurrence, so that data from different sites can be compared directly. For studies of population dynamics or dispersion, this technique is essential (Cameron, 1982; Sharland, 2001; Cameron, 2003). Even in such studies, errors can arise if snails hide below the depth to which soil and litter are taken (Sharland, 2001).

However, as many authors have discovered, this method alone is inadequate when a complete inventory of species in a site is required. When the life histories and ecology of mollusc species are considered, it is possible to identify two major sources of error. Some species are affected by both.

#### 1. Abundance and distribution make quantitative sampling very inefficient.

1.1. Large species (in Europe, helicoids such as *Helix* spp., *Cepaea* spp., *Arianta arbustorum*, *Bradybaena fruticum*) often occur at low densities, and are locally aggregated, so that they are missed quite frequently in modest programmes of genuinely random sampling. The same problem affects the larger slugs.

1.2. Slugs are known to be more difficult to collect during daytime (Wäreborn, 1969). Many may rest some considerable distance underground (Wiktor, 1989), and be missed even when all litter is removed from a quadrat. Some of them fall in category 1.3 (below). Additionally, when the samples are not processed immediately, which is often the case, the slugs die and decompose rapidly. Slug species rather regularly found in quantitative samples are almost exclusively small species of *Arion* (*A. circumscriptus*, *A. silvaticus*, *A. fasciatus* and *A. distinctus*; Dzieczkowski 1972, 1988, Szybiak 2000, 2002).



TABLE 4

Species with disproportionate distribution between quantitative (quant) (Oekland samples) and qualitative (qual)(visual search) samples. Pieniński Potok, Pieniny Mts, Carpathian beech forest; data from Szybiak (2000). Species that are easier to find with quantitative methods indicated in bold.

Species	quant	qual	Species	quant	qual
<i>Acicula polita</i>	22	0	<i>Acanthinula aculeata</i>	10	0
<i>Aegopinella pura</i>	63	2	<i>Vitrea transsylvanica</i>	31	5
<i>Vitrea diaphana</i>	96	0	<i>Oxychilus orientalis</i>	4	34
<i>Cochlodina laminata</i>	0	42	<i>Cochlodina orthostoma</i>	1	10
<i>Macrogastra tumida</i>	9	36	<i>Macrogastra plicatula</i>	4	50
<i>Macrogastra ventricosa</i>	11	182	<i>Clausilia dubia</i>	0	18
<i>Vestia gulo</i>	30	201	<i>Vestia turgida</i>	5	25
<i>Bradybaena fruticum</i>	0	10	<i>Arianta arbustorum</i>	0	5
<i>Helix pomatia</i>	0	25	<i>Limax cinereoniger</i>	1	6
<i>Bielzia coerulans</i>	0	20			

TABLE 5

Basic statistics for the percentage of species missed during quantitative (quadrat) sampling in various types of forest. For data sources see text.

Forest type	Proportion of missed species				
	range	mean	SE	SD	n
lowland beech	36.0-64.3	48.9	2.50	8.29	11
Carpathian beech	3.5-67.5	34.3	4.53	18.12	16
oak-hornbeam	29.1-61.1	41.8	3.53	11.18	10
alder	23.3-59.4	38.9	5.80	14.20	6
ash-elm	30.8-61.1	41.7	5.94	13.27	5

1.3. Tree-, log- and rock-dwellers occupy microhabitats that are patchily distributed, and may escape sampling. Besides limacid slugs (Wiktor 1989), this category includes snail species that rarely stay in ground cover during the active season (e.g. the majority of clausiliids, *Ena montana* and *E. obscura*, *Helicigona lapicida*). A good example is *Helicodonta obvoluta*, which spends the active season on, and the remaining part of the year in, large rotting logs. Some few individuals can be found in leaf litter during a very short period when the snails leave the logs in autumn to enter the rotting wood from below, or when they search for a new log when the old one has decomposed (Maltz, 2002).

2. Seasonal variation in density and microdistribution.

2.1. Many species have short life cycles, and their density undergoes drastic seasonal fluctuations. *Vertigo pusilla* is a good example. In extreme cases its density may drop from nearly 1000 m<sup>-2</sup> in spring to a few in late autumn or winter (Pokryszko 1990a). Other tiny species such as *Punctum pygmaeum* are likely to be similar (Baur 1989). The situation is similar with some vitrinids (*Semilimax kotulai*, *Eucobresia diaphana*, *E. nivalis*; Umiński 1975, 1983) and slugs (*Limax tenellus* and *Deroceras praecox*) (Wiktor 1989).

TABLE 6

A comparison of results of volume (20 litres) and quadrat sampling (3.25 m<sup>2</sup> of substrate removed) in limed (eutrophic) and unlimed (oligotrophic) forest sites in Sweden (Gärdenfors, Waldén and Wäreborn, 1996). The authors give other examples. + indicates a fresh empty shell.

	Limed Site		Unlimed Site	
Species	Volume	Oekland	Volume	Oekland
<i>Columella aspera</i>	2	0	1	0
<i>Vertigo pusilla</i>	2	0	0	0
<i>Vertigo substriata</i>	7	2	0	0
<i>Punctum pygmaeum</i>	76	312	16	0
<i>Discus rotundatus</i>	2	8	0	0
<i>Nesovitrea hammonis</i>	32	275	11	9
<i>Oxychilus alliarius</i>	2	30	0	0
<i>Euconulus fulvus</i>	81	618	7	4
<i>Cochlodina laminata</i>	1	2	+	0
<i>Clausilia bidentata</i>	3	1	1	0
Species	10	8	6	2
Individuals	209	1248	36	13

2.2. Some species show an apparent decline in density under unfavourable conditions. Members of this category are small or medium-sized species, which, during drought become more difficult to find, as they hide below the level to which litter/soil samples are taken, thus giving an impression of a decline in population density (e.g. *Vitrina pellucida*, *Euconulus fulvus*; Umiński and Focht 1979; *Vertigo geyeri*, Sharland, 2001).

2.3. Patterns of aggregation can change with season. Out of ten species studied in this respect in the nature reserve Muszkowicki Las Bukowy (Kuźnik-Kowalska 1998), *Balea biplicata* showed a clustered distribution during eight months in 12, *Acicula polita* and *Columella edentula* during three months, and *Discus perspectivus* during two months. Reasons for such aggregation are not always clear. In the case of *C. edentula* it is probably associated with the habit of climbing herbs (e.g. *Asarum europaeum*, *Mercurialis perennis*), which are also patchily distributed (Pokryszko 1990b). Clustering in favourable resting places during aestivation and hibernation also contributes to aggregation.

To varying degrees, these problems mean that Oekland sampling alone does not give adequate inventories, Some authors have supplemented their Oekland samples with a visual search in the area concerned, or have compared such sampling with other techniques. As an example, the data in Szybiak (2000) can be used to compile a list of species that were absent from or underrepresented in her quantitative samples (Table 4). Larger snails and slugs are most often missed, while small litter-dwelling species are more efficiently retrieved in the quadrats than by visual search. Dzieczkowski (1972, 1988), and Szybiak (2000, 2002) have made many such studies. From a total of 48 of their sites in Poland, it is possible to examine the effects of adding species found only by visual searching (Table 5). The percentage of species missed during quantitative sampling ranges from 3.5 to 67.5 and is not correlated with the surface area sampled ( $R = -0.037$ ) or with the number of seasons included in the study ( $R = 0.087$ ). The material is too scanty to draw further statistical conclusions, but there seems to be little difference between the types of forest habitats.

TABLE 7

Number of species of snails and slugs recorded in five woodland nature reserves in the Cotswolds, England. DCL, records made by D.C Long over the whole area, mainly by visual searching, but representing many visits. RC/BP, litter volume and visual search in 1-3 400 m<sup>2</sup> plots within each wood. While more detailed analyses are in preparation, it can be seen that slugs show greater proportional deficiency in the RC/BP data.

	Siccaridge	Workman's	Pope's	Rough Park	Midger
Snails DCL	41	38	26	30	33
Snails RC/BP	37	33	29	30	28
Slugs DCL	16	12	10	11	15
Slugs RC/BP	10	9	6	4	6

VOLUME METHODS

Because of the immense variability associated with Oekland samples, some authors have chosen to sieve a definite volume (usually 10 or 20 l) of litter and soil from patches selected non-randomly within a defined area (Waldén 1955, 1978, 1981, Valovirta 1968, Wäreborn 1969). When quantitative results were needed, they could be standardised either by taking the same volume of litter at each site, or by estimating mean number of individuals of each species per unit volume. This method is strictly incomparable in terms of absolute density as it is impossible to convert the number of specimens/ m<sup>-2</sup> to the number per litre and *vice versa*.

This approach, while more dependent on skill and the judgement of the investigator, seems to give more consistent results when sites with similar environmental conditions are compared. We are aware of only two direct comparisons. Gärdenfors, Waldén and Wäreborn (1996) compared methods in limed and unlimed forest sites in Halland, Sweden (Table 6). In this case, despite yielding fewer specimens in the limed site, the volume method detected more species in both cases. However, some species were more numerous in Oekland samples. This ratio can vary with season; in the other study (Kuźnik1997, Kuźnik-Kowalska 1998) quadrats were more efficient with regard to *Acicula polita* from July till October, while volume sampling yielded better results in the case of *Acanthinula aculeata* only from June till August. The two methods differed in their overall efficiency, and their efficiency with respect to particular species, and their relative efficiency varied seasonally. However, the volume method rarely failed to detect a species revealed by the Oekland method, and in this case it involved the collection and sorting of a smaller amount of material.

In nearly all cases where the volume method is used, investigators have combined it with a visual search in a defined area, often with a defined amount of collecting effort (Waldén, 1981; Emberton *et al.*, 1996; Menez 2001; Cameron and Pokryszko 2004). In at least one case (Maltz, unpublished), the proportion of species added by the visual search is similar to those recorded in the Oekland comparison given earlier (table 5) (mean, 34%). Some preliminary work is needed (Menez, 2001) to determine the appropriate level of effort. Later work in some of the sites studied by Cameron (1973) demonstrates



that the site species richness values originally recorded were serious underestimates resulting from inadequate volumes of litter and too short a searching time (Cameron, Pokryszko and Long, unpublished).

### VISUAL SEARCH ALONE

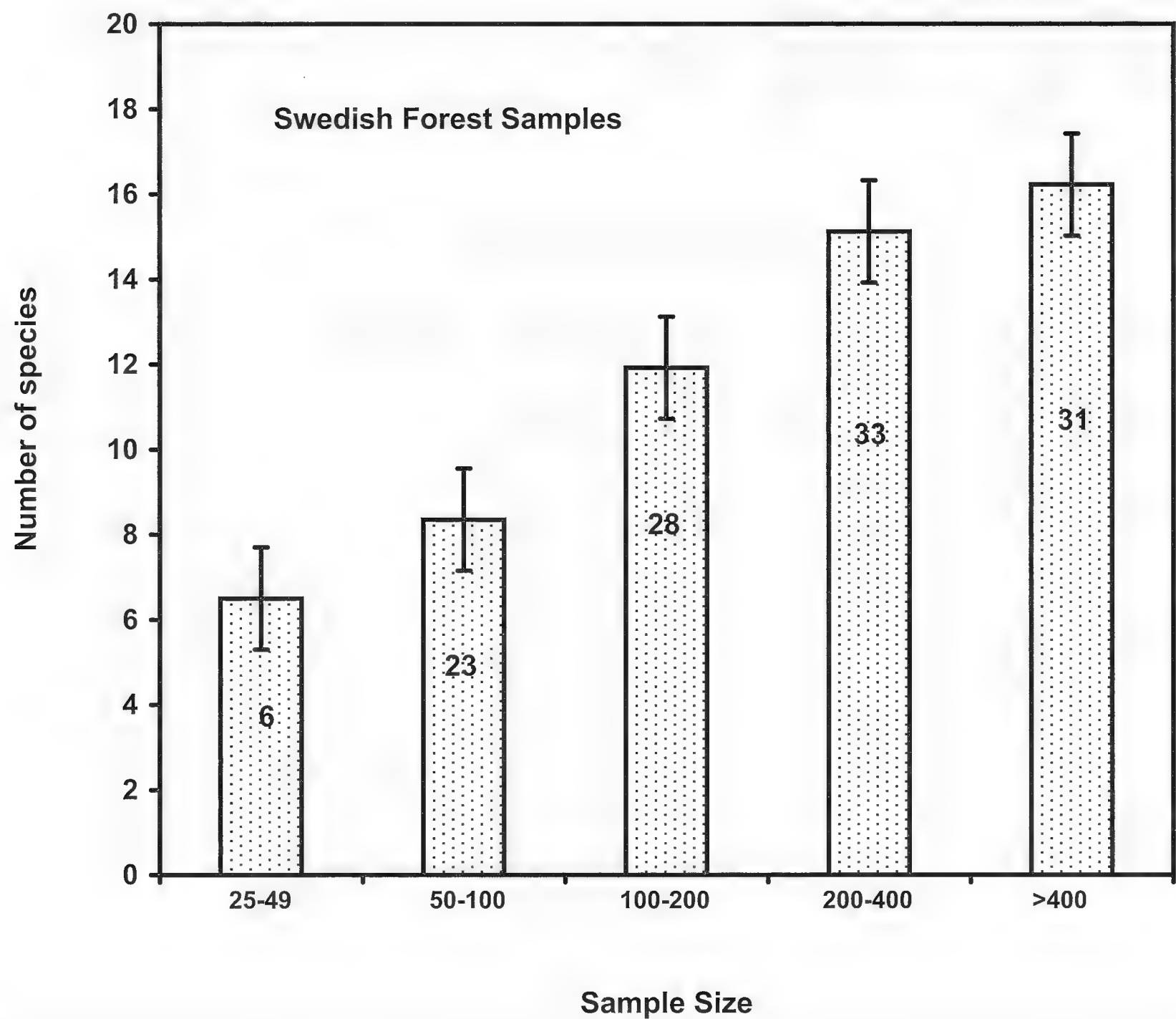
Data given above show that the sampling and sieving of litter, however collected, improve the chances of finding small and cryptic species. Both Oekland and volume techniques, however, can miss many of the larger and more patchily distributed species. Furthermore, the time taken to process such samples is considerably greater than that required by those made by hand collecting specimens in the field (Emberton *et al.* 1996).

Hence, where an inventory of a district is required, and it is possible to make numerous samples within it, visual search alone may be the most efficient strategy (Cowie, 2001; Cowie and Robinson, 2003). Thus, while the results of Cameron (1973), referred to above (page \*\*\*), turned out to be inadequate on a site-by-site basis, the fauna recorded for the district and habitat overall was virtually identical to that recorded by later, more thorough sampling (Cameron, Pokryszko and Long, unpublished). The same conclusions apply to the work of de Winter and Gittenberger (1999) and of Schilthuizen and Rutjes (2001), where it is clear that the faunas of the study areas are better recorded than those of individual plots within them. In all these cases, litter samples were taken in addition to visual search, but the same principle applies: a number of inadequate site samples may provide an adequate district inventory.

As with the volume method, though, results can depend on the skill and experience of the workers involved (Ward-Booth and Dussart, 2001). Where a mixed technique is used, visual search may be aimed primarily at large species. It is hard to make a direct comparison between the dual method approaches discussed here and the old (Boycottian) approach of many visits with visual searches alone, because the latter usually refer to substantially larger areas. In effect, repeated visual searches replicate in time the effect of many visual searches among sites in a district. If we compare our own results (Cameron and Pokryszko, unpublished) from 400 m<sup>2</sup> plots in some Cotswold woodlands that were surveyed over larger areas, but with many visits, by D.C. Long (unpublished), it is apparent that our single visit investigations do well for snails, but much worse for slugs (Table 7): a single visit is rarely capable of finding the whole slug fauna.

### PRACTICAL ISSUES

Different studies have different aims. In what follows, we are concerned with studies that aim to provide complete inventories for defined areas, and in particular to small (< 1 ha) sites. Thus, studies concerned with population density, for example, require the identification of individuals alive at the time of sampling. However, some of the problems associated with Oekland, volume and mixed techniques of sampling can be reduced by including fresh, but empty, shells in the inventory. Most of the studies referred to above have included such shells in their analyses. Including these increases sample size, and overcomes some of the seasonal variation mentioned above. In oligotrophic environments, and for thin-shelled species, it is unlikely to introduce the error of including species not now living in the site. Rundell and Cowie (2004) found moderate levels of rank correlation between numbers of live specimens and fresh empty shells in a study on Pacific islands, sufficient to justify the use of the latter in inventories. In the stable environment



**Figure 7** Mean numbers of species found in samples from Swedish forests, categorised by sample size. Error bars represent the average confidence limits; numbers in each bar indicate the number of localities. Data from Gärdenfors *et al.* (1996) and Wäreborn (1969).

of a Shropshire wood (Cameron, 1982 and unpublished) numbers of live individuals and fresh empty shells were highly correlated between species, but two species were detected only as empty shells. Care has to be taken, however, not to include ancient or subfossil shells that can be found quite often in calcareous areas, and there are cases, as on the Magnesian Limestone of eastern England, where a species, in this case the helicoid *Helicigona lapicida*, has not been found alive for more than 20 years, but dead shells are still found occasionally; evidence from many sources suggests that there has been a genuine range contraction (W. Ely, unpublished).

We have considered issues of time and effort in relation to the reliability of results only briefly. In this context, the work of Emberton *et al.* (1996) is essential reading, especially where time and personnel constraints are pressing. Where plot/site inventories are a minor consideration, and searchers are skilled, there is a case for visual search only.

The area of site chosen will also vary with the purpose of the investigation. For detailed ecological studies, small sites may be best: Magnin and colleagues have been able to identify environmental relationships using areas of 25m<sup>2</sup> (Kiss and Magnin, 2003), while others have used areas ranging from 400m<sup>2</sup> (Cameron and Pokryszko, 2004) to a hectare or more, where the aims are more biogeographical. The slope of the species/area relationship over this range of areas is usually very slight, provided the habitat is of the same kind throughout (Nekola and Smith, 1999; Cameron, 2004), but at much smaller scales there will be more heterogeneity as the chances of missing particular microhabitats increase (Cameron *et al.*, 2003).

In our own experience in Europe, the principal difficulties with a mixed volume/ searching strategy relate to sample size in oligotrophic places, and to slugs. In other

regions where a significant number of species spend long periods high up in trees, there is clearly another difficulty. Without considering the last, we suggest the following points should be taken into account when sampling, and when analysing inventory data.

1. Samples are best made by a combination of litter collection and visual searching within the active season for most of the fauna. When fresh shells are included, out-of-season collection may be adequate for snails (Cameron, 1992). In the European forest context, 10 litres of litter and two person-hours of searching appear to be adequate for calcareous sites; more might be needed in oligotrophic conditions. Most of the Swedish studies referred to below have taken 20 litres per site.

2. Unless population density estimates are required for some species, there is no particular virtue in taking randomised Oekland samples. A standard volume of litter, taken from patches within the site and analysed as a bulk sample, is easier to take, and at least as reliable for inventory purposes. There is no information in the literature as to the number of patches involved; this has clearly varied from study to study, and from site to site within studies.

3. Slugs cannot be reliably inventoried by a single visit. Note that "semi-slugs" (e.g. vitrinids) and small snail species with short life cycles can be inventoried by single visits if fresh shells are included, and species are identifiable from such shells.

4. Samples should contain at least ten times as many individuals as there appear to be species present. This is a bare minimum, which will not always detect the rarest species. Even for species-poor faunas, a minimum of 200 individuals is highly desirable. This advice is very pragmatic: for very rich faunas, rather more than ten times as many individuals are theoretically necessary. Inspection of a number of data sets from Sweden (Gärdenfors *et al.*, 1996; Wäreborn, 1969) (figure 7) shows that above 200 individuals the relationship between number of individuals and number of species seems to disappear. The richest of these sites hold 21 species. There is no significant difference between the mean numbers of species retrieved between the two largest sample categories, nor are there significant correlations on a sample-by-sample basis for samples of more than 200 individuals. Cameron, Pokryszko and Long (unpublished) found no relationships between number of individuals and number of species in a study in England where site totals ranged from c300 to c.1000 individuals and 22 to 35 species. Three supplementary points need emphasis here:

- (a) For species that are readily identified in the field, actual collection is not essential; they can be tallied on the spot. This may be a matter of mere convenience: handling large numbers of live specimens of large species may be burdensome. More importantly, rare species should not be removed unless the specimens are required for other purposes.

- (b) Strictly speaking, it is not necessary for inventory purposes to count all the individuals seen or collected, especially if the numbers are clearly large. Counting and extraction of many individuals of tiny species imposes a significant cost in time. However, there are non-parametric tests for completeness which depend on accurate records of species represented by one and two individuals only, and a full count, converted into a rank/ abundance diagram (e.g. figures 4-6) enables the frequency distribution to be examined (see item 6, below).

- (c) If a number of plots are sampled in a cluster, and appear to be from the same habitat, the combined total may give a more complete inventory of the species to be found in that locality and habitat. This may be the only practical way of inventory in places with high diversity but low density. For example, in the study by Schilthuizen and Rutjes



(2001), the “times ten” rule mentioned above would require samples of c.500 individuals from each plot, against an achieved mean of 11. An aggregate total for a cluster would need to be around 800-1000, still higher than the 353 obtained, but more feasible. The problem of interpreting differences between such plots will remain. If the degree of difference within clusters, estimated by Whittaker’s Index, or any similar measure, is inversely related to sample size, a sampling error effect should be suspected.

5. In a number of studies, consideration of adjacent sites in the same general habitat type shows a lack of an asymptote, i.e. as more sites are added, the total of species continues to rise. This could be taken to mean that sampling is, so far, inadequate for revealing true species richness. It is important to realize that this could also be a consequence of genuine differences among sites. The detection of genuine local patchiness requires good samples from each site involved.

6. There are two relatively straightforward ways of checking the adequacy of the sampling regime.

(a) Among the various non-parametric statistical tests available, the easiest, and perhaps the most robust (Gotelli and Colwell, 2001) is the Chao estimator, based on either numbers or frequency of occurrence in quadrats/samples from the same habitat and location (Southwood and Henderson, 2000). Chao estimates the number of species present, but not found, as given by:

$$(\text{number of singletons})^2 / 2 \times (\text{number of doubletons})$$

It can be used with numbers of species represented by one or two individuals, or, where many quadrats have been made, by the number of species occurring in only one or in two quadrats. When these numbers are small, the standard errors are large, but the estimator provides a check on completeness. As in 5 above, care needs to be taken when frequency in a number of sites is used; genuine differences among them will exaggerate the degree to which richness is underestimated.

(b) A rank/abundance plot gives an indication of the frequency distribution of the species found (e.g. figures 4-6). If it has a convex form when a logarithmic plot of frequency is used, the implication is that the sample is including some of the rarest species. If it is concave (c.f. figure 5), with many very rare species showing little difference in frequency, more species might be revealed by a modest increase in sample size. A concave form might also suggest that there is a suite of rare species that are patchily distributed in the study area.

7. From a statistical perspective, in making inventories, there is no need for samples to represent equal amounts of effort, or volume of litter sieved. For a given frequency distribution, it is more important that the numbers of individuals sampled are similar, and that these numbers are sufficient. **Hence, in poor sites, there is every reason to increase time spent, or volume sieved.** It does not invalidate comparisons, provided all samples show evidence of being +/- complete in terms of species present. Such standardisation can also be achieved by rarefaction or comparison of species accumulation curves as regards richness alone, but these techniques are less useful when compositions are compared.

8. Short of wholesale habitat destruction, it is impossible to be sure that all species present have been found. Studies of very rare species (in terms of numbers, or of number of sites in which found) require a more focussed approach that may not provide good general inventories.

One of the major challenges in the ecology and biogeography of terrestrial molluscs is to determine the scales at which patterns of distribution occur, and the extent to which they correlate with environmental variation at small scales (Cameron, Mylonas, Triantis, Parmakelis and Vardinoyannis, 2003; Cameron and Pokryszko, 2004). Such determination requires both sampling at more than one scale, and a high degree of confidence in the completeness of inventories at all scales. Re-examination of the data reviewed in Cameron (1995) suggests that the degree of local differentiation (shown by values of Whittaker's Index) among sites in various European forests is often significantly exaggerated by sampling error. The same applies to a number of tropical studies.

### ACKNOWLEDGEMENTS

RADC thanks the Royal Society of London for a short-term study visit grant for work in Poland. We are grateful to David Long for allowing us to use unpublished data from his very thorough surveys of Cotswold woodlands. We are also grateful to Dr. Robert Cowie and Dr. Jeff Nekola for suggestions and critiques of an earlier version.

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# LAND MOLLUSCS ON THE ISLES OF SCILLY: SPECIES RICHNESS AND COMPOSITION RELATED TO AREA

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*Abstract* Variation in the species richness and composition of land mollusc faunas from seven islands in the Isles of Scilly is analysed in relation to island area and human activity. Comparisons are made with other island faunas, and with those from appropriate areas of mainland Britain. Whereas the faunas of the largest and most heavily populated island, St. Mary's, and of the archipelago as a whole, are as rich as those found in the same areas of mainland, the smaller islands are species-poor, and conform to the species/area relationship normally found amongst islands. The islands' faunas are heavily influenced by human activity; introduced species are numerous, but native woodland and wetland specialists are few. Comparisons with other islands and areas of mainland reinforce these conclusions.

*Key words* Species/area relationships, land molluscs, Isles of Scilly, human influence, persistence.

## INTRODUCTION

Continental shelf islands are usually species poor compared to the same areas of mainland, and the slope,  $z$ , of the logarithmic species/area regression is steeper than that within a mainland region (Rosenzweig, 1995). While the balance of causes varies, this is generally held to be a consequence of lower immigration rates and higher extinction rates on the islands, with both being affected by the size and isolation of the islands concerned (Rosenzweig, 1995; Lomolino and Weiser, 2001). Especially in smaller islands, the range of environments available may affect the species richness independently of area (Lomolino and Weiser, 2001; Triantis, Mylonas, Lika & Vardinoyannis, 2003).

For larger ( $>4 \text{ km}^2$ ), inhabited islands around the coasts of Britain, this is not true for land molluscs; such islands have numbers of species appropriate to the same area of mainland (Cameron, 2002 a & b). This is due in part to human intervention, which increases the rate of immigration and creates new habitats suitable for anthropochorous species (Cameron, 2002 b). A similar effect is known amongst Aegean island mollusc faunas (Mylonas, 1984). Since offshore islands in Britain were mostly connected to the mainland in the early Flandrian or even later, however, their richness may owe something to persistence: viable land mollusc populations can survive in very small areas of suitable habitat. Details of species composition suggest that both the above play a part, though to varying degrees.

In April 2003, one of us, GAH, was able to survey the land mollusc faunas of seven islands in the Isles of Scilly (Holyoak, 2003). Five of these are inhabited by humans, and all but one (St. Mary's) are smaller than  $4 \text{ km}^2$  in area. These systematic surveys can be combined with earlier records (Turk, Meredith & Holyoak, 2001) to give adequate records for the islands concerned. In this paper, we analyse the species richness and composition of the islands' land mollusc faunas, and compare them with those from other islands in the English Channel area, and with the fauna of Cornwall as a whole.

## THE ISLANDS AND OTHER AREAS STUDIED

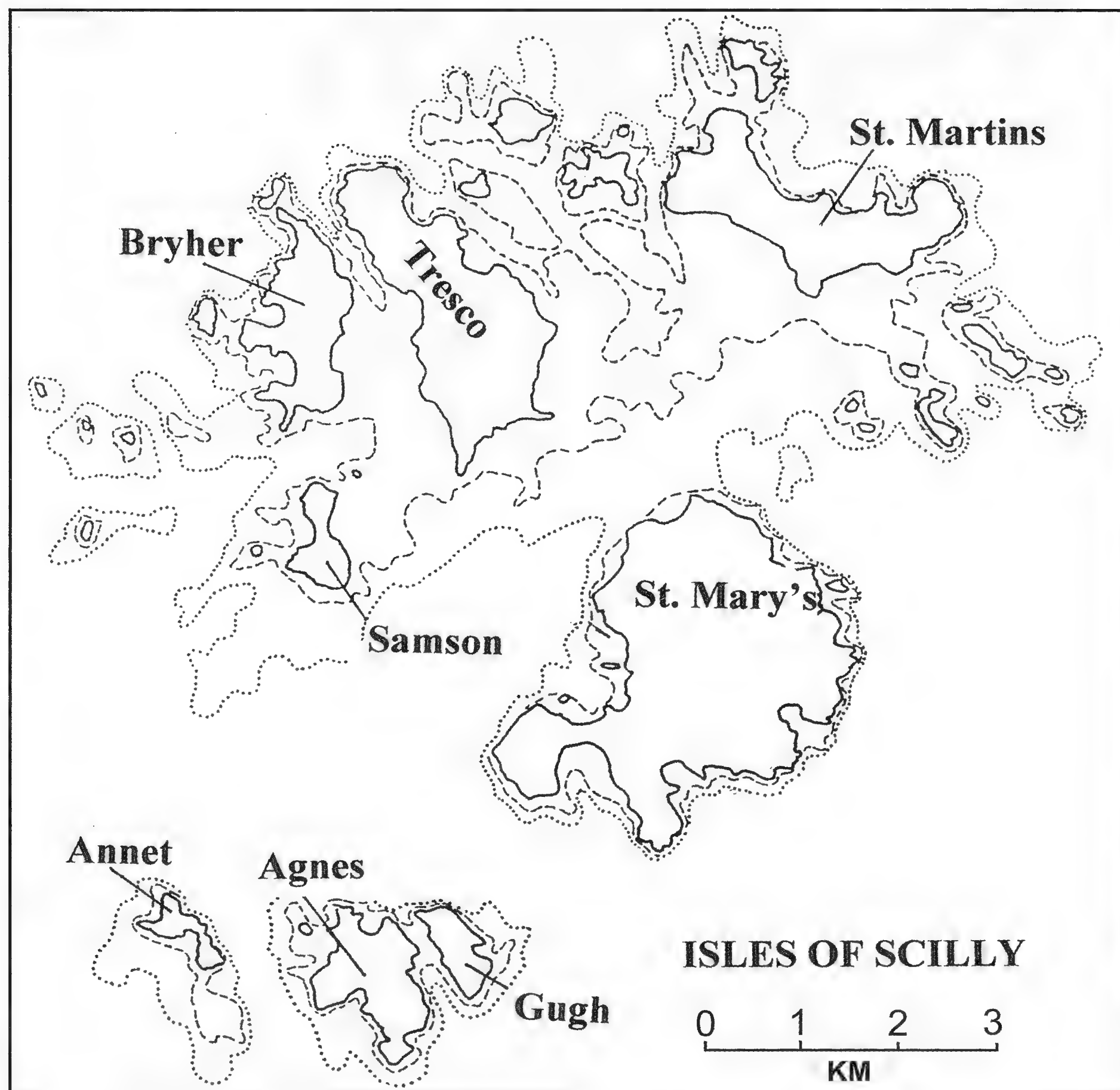
The Isles of Scilly form an archipelago about 40 km WSW of the westernmost point of mainland Cornwall. There are 18 islands carrying terrestrial vegetation and many barren

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**Figure 1** The Isles of Scilly, showing the islands surveyed by GAH, and the estimated coastlines at 1200 BC (dotted line), and at 800 AD (dashed line). The figure is derived from Thomas (1985).

islets, but only five islands now have permanent human settlements (Figure 1, Table 1), and these are much the largest. The total land area is approximately 16 km<sup>2</sup>. The solid geology is of Palaeozoic igneous rock (granites). There is blown sand on all the larger islands, but it is siliceous; lime-rich sand from comminuted seashells is very localised.

Thomas (1985) gives a detailed account of the islands' history since the last Glacial maximum. The whole archipelago was joined to the mainland in the late Devensian, separating at least 11,000 years ago. It, in turn, is the remains of a larger island partly submerged by rising sea levels; while outlying islands became isolated well before 1200 BC, others may have been joined together as recently as 800 AD (Figure 1). Neolithic farmers had settled by c. 2000 BC, long before the final disintegration.

The predominant vegetation types today are coastal heaths, cultivations, abandoned fields and a much smaller amount of wetland. Due to the mild climate, a considerable number of alien plant species are naturalised, and there is a considerable horticultural trade with the mainland. No natural woodland survives, and there are small plantations only on St. Mary's and Treco, which also have small areas of *Salix* carr.

For comparison, we have considered the fauna of Cornwall as a whole, of three islands similar in size to St. Mary's, and of a semi-isolated area of mainland Britain, also

roughly the same size. Alderney and Sark, in the Channel Islands, have a similar solid geology to that of Scilly. Both were originally part of the French mainland, Alderney becoming isolated about 9000 years ago, while Sark separated from France rather earlier, but from Guernsey at about the same time (Renouf and Urry, 1976 and 1986). The range of vegetation is not very different to that on Scilly, although calcareous blown sand is more plentiful on Alderney, which also supports a large number of ruined fortifications. Lundy, in the Bristol Channel, again has a similar solid geology and range of habitats, and again is a block separated from the mainland by rising sea levels.

The mainland comparison is with the South Haven Peninsula at the mouth of Poole Harbour in Dorset. This area, also very acidic, has a different history, having been built up in historic times by sand accumulation. It contains a wider range of habitats, including woodland, but has virtually no agricultural activity (Cameron, 2001). Although relatively distant, it is used to examine the richness of a mainland area of similar size, sampled at a similar intensity. Details of the area and human population of these places are given in Table 1.

### SPECIES AND RECORDS CONSIDERED

We have considered only truly terrestrial species, omitting *Ovatella* and *Leucophytia*. Records for the Isles of Scilly and Cornwall come from the Atlas for Cornwall (Turk *et al.*, 2001) with minor corrections and later additions, and from the surveys conducted by GAH in April 2003. Records from elsewhere come from the national Atlas (Kerney, 1999), or from Cameron (2001). Atlas records for Alderney and Sark include the results of surveys by RADC in 1996. Nomenclature follows Kerney (1999).

We have omitted pre-1960 records that have not been confirmed since. Some of these may be errors; others probably represent short-lived introductions. Details of these records on Scilly can be found in Turk (1991). For the South Haven Peninsula, however, they may represent local extinctions following environmental change (Cameron, 2001).

No survey can be guaranteed to reveal all the species living in an area. Our detailed analyses do, however, refer to places where a systematic effort was made to survey the range of habitats available. On Scilly, GAH surveys involved several days on St Mary's, two days each on Tresco and St Agnes, a day on St. Martin's and half a day each on the remainder, Bryher, Samson and Annet. Atlas records for Scilly include records from other small, uninhabited islands. No species so recorded is missing from the seven islands surveyed by GAH; since they represent only casual recording, the islands involved are not included in the analysis.

Lundy has been thoroughly surveyed, as has the South Haven Peninsula. RADC's surveys on Alderney and Sark both took place over a week, involving many sites; on Sark, however, extreme drought conditions certainly affected the discovery of slugs.

## RESULTS

### ISLAND FAUNAS

Table 1 shows the presence of species on each of the islands studied by GAH, including all *post* 1960 records verified by the authors. It gives the same data for Alderney, Sark, Lundy and the South Haven Peninsula, excluding species not found on Scilly (see below), which are, however, included in the Total + Extras rows. It also gives the area and the estimated resident human population for each.

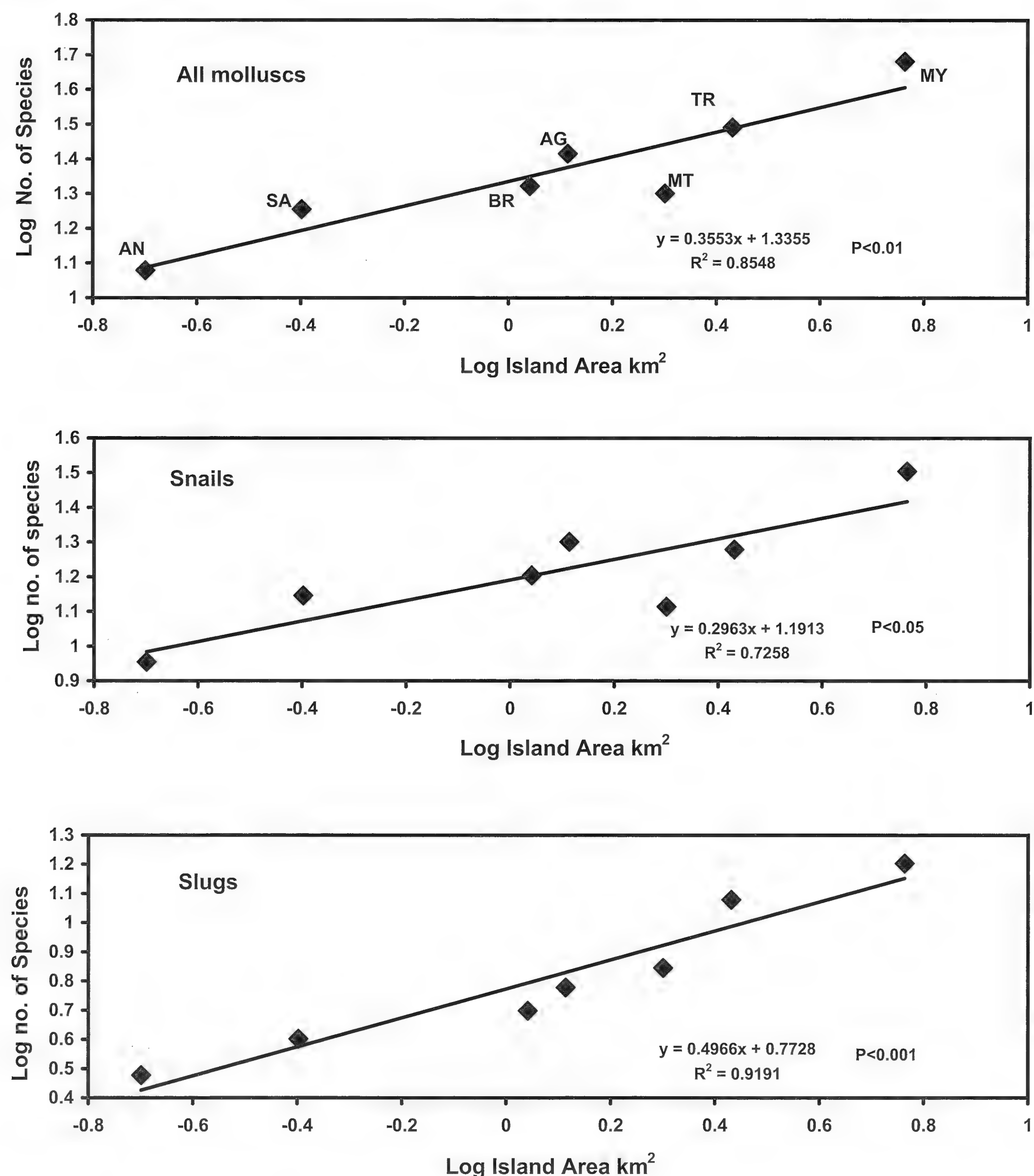
51 species are recorded on the Isles of Scilly overall, one of which, *Arion circumscriptus*

TABLE 1  
The occurrence of snail and slug species on the seven Scilly islands investigated and their occurrence in four other localities (see text ). Data is also given on the areas involved and the human population. For localities not in the Scilly islands the totals of species recorded (Total + extras) is also given. Note that the area given for St Agnes includes that of Gugh, connected at low tide.

Snails	St Mary's	Tresco	St Agnes	Bryher	St. Martin's	Samson	Annet	Alderney	Sark	Lundy	SHP
<i>Carychium minimum</i>	1								1	1	1
<i>Carychium tridenatum</i>	1								1	1	1
<i>Oxyloma pfeifferi</i>	1							1			
<i>Cochlicopa lubrica</i>	1	1	1	1	1	1	1	1	1	1	1
<i>Cochlicopa lubricella</i>	1		1		1	1		1	1		1
<i>Columella aspera</i>	1	1	1	1	1	1				1	1
<i>Vertigo pygmaea</i>	1							1			1
<i>Leiostylia anglica</i>	1								1	1	
<i>Lauria cylindracea</i>	1	1	1	1	1	1	1	1	1	1	1
<i>Vallonia excentrica</i>	1							1		1	1
<i>Discus rotundatus</i>	1	1	1	1	1	1	1	1	1	1	1
<i>Vitrina pellucida</i>	1	1	1	1		1	1	1	1	1	1
<i>Vitrea contracta</i>	1		1					1	1	1	1
<i>Nesovitrea hammonis</i>	1	1	1			1		1		1	1
<i>Aegopinella nitidula</i>	1	1	1	1	1	1	1	1	1	1	1
<i>Oxychilus draparnaudi</i>	1	1	1					1	1	1	1
<i>Oxychilus cellarius</i>	1	1		1				1	1	1	1
<i>Oxychilus alliarius</i>	1	1	1	1	1	1	1	1	1	1	1
<i>Zonitoides nitidus</i>	1										
<i>Zonitoides excavatus</i>	1									1	
<i>Eucomulus fulvus</i>	?		1							1	1
<i>Eucomulus alderi</i>	1									1	1
<i>Clausilia bidentata</i>	1							1	1	1	1
<i>Balea perversa</i>	1	1	1	1	1			1		1	
<i>Candidula intersecta</i>	1	1	1	1	1	1		1		1	1
<i>Cernuella virgata</i>	1	1	1			1		1	1		1
<i>Cochlicella acuta</i>	1		1			1	1	1			1
<i>Ashfordia granulata</i>	1	1	1	1	1			1		1	
<i>Trichia striolata</i>	1	1		1				1		1	1
<i>Trichia hispida</i>	1	1		1				1	1	1	1
<i>Ponentina subvirescens</i>	1	1	1	1	1					1	







**Figure 2** Log<sub>10</sub> species/ area relationships on the Isles of Scilly for all molluscs, and for snails and slugs separately. Island abbreviations: AG, St Agnes; AN, Annet; BR, Bryher; MT, St Martin's; MY, St. Mary's; SA, Samson; TR, Treco.

agg., cannot be assigned unambiguously to a particular species. It is evident that the largest, and most heavily populated island, St. Mary's, has much the richest fauna. Nearly all species found on Scilly as a whole are present. There is a strong and significant logarithmic species/ area relationship between islands, for the fauna as a whole, and for slugs and snails considered separately (Figure 2). The slope is steeper, and the significance of the relationship is greater, for slugs than for snails.

There are individual peculiarities. St. Martin's has a smaller snail fauna than expected, while Treco has an exceptional slug fauna. Collecting effort by GAH was less, proportional to island area, on St. Martin's than elsewhere, and greatest on St. Mary's,

TABLE 2

Universal, near universal and single island species recorded on the Isles of Scilly. Note that there is an aggregate record of *E. fulvus* from St. Mary’s.

Species on all 7 islands	Species only on St. Mary’s	Species only on:
<i>Cochlicopa lubrica</i>	<i>Carychium minimum</i>	St. Agnes
<i>Lauria cylindracea</i>	<i>Carychium tridentatum</i>	<i>Euconulus fulvus</i> seg.
<i>Discus rotundatus</i>	<i>Vertigo pygmaea</i>	
<i>Aegopinella nitidula</i>	<i>Leiostyla anglica</i>	Samson
<i>Oxychilus alliarius</i>	<i>Vallonia excentrica</i>	<i>Arion circumscriptus</i> agg.
<i>Cepaea nemoralis</i>	<i>Zonitoides nitidus</i>	
<i>Helix aspersa</i>	<i>Zonitoides excavatus</i>	Tresco
<i>Arion ater</i> agg.	<i>Euconulus alderi</i>	<i>Boettgerilla pallens</i>
	<i>Clausilia bidentata</i>	
Species on 6 islands	<i>Arion flagellus</i>	
<i>Columella aspera</i>	<i>Arion distinctus</i>	
<i>Vitrina pellucida</i>	<i>Limax flavus</i>	
<i>Candidula intersecta</i>	<i>Tandonia budapestensis</i>	

which also has more earlier records. Nevertheless, if the faunas of all islands other than St. Mary’s are combined, roughly equalising collecting effort, and representing a slightly larger area (7.7 km<sup>2</sup>), they hold 37 species, compared to 48 on St. Mary’s. The area relationship is not just a product of sampling intensity.

Eight species are found on all seven islands, and three more species on six of them (Table 2). All are species of wide habitat tolerance, except *C. intersecta*. This species, together with *C. nemoralis* and *H. aspersa*, is often abundant in open coastal habitats. At the other extreme, 13 species are known only from St. Mary’s, and one each only from Samson, Tresco and St. Agnes (Table 2). With the exceptions of *V. excentrica* and *V. pygmaea*, the snails unique to St. Mary’s are species typically associated with wetland or woodland. Amongst slugs, the recently introduced *L. valentiana* is found on all inhabited islands, while on the uninhabited islands the only typically anthropochorous species is *T. sowerbyi*.

WIDER COMPARISONS

Comparisons can be made with the three other islands and the mainland peninsula described above. Amongst these, the fauna of Sark may be under-recorded (RADC, unpublished data). Table 1 shows the species held in common with Scilly, and the overall totals. Table 3 lists the species in each not found on Scilly. The overall levels of richness are very similar to that of St. Mary’s, or to that of Scilly as a whole. With the exception of *A. ater*, missing on Sark, all the universal species on Scilly also occur in all four locations. All species occurring in all four locations also occur on St. Mary’s. Considering the other islands only, there are nine snail species not found on Scilly, but only two slugs. It is noticeable that the South Haven Peninsula, and to a lesser extent, Lundy, hold woodland species not recorded on Scilly, such as *A. aculeata* and *E. obscura*.

Table 4 lists the species recorded in Cornwall as a whole, since 1965, which have not been recorded recently from Scilly. Of these, a substantial number are typically or exclusively woodland species, and a smaller number are typically calcicole, or are species of rich open wetland. A larger number, however, are of broad habitat tolerance, or are anthropochorous. 22 of the 35 species listed are rare in the Cornish context, being recorded from less than 10 tetrads in the County Atlas (Turk *et. al.*, 2001), whereas this is true of only five of the 51 species also recorded for Scilly. Two of the five are the segregates of *Euconulus*; aggregate records in the county are more numerous. Even



TABLE 3

Species recorded on Alderney, Lundy and the South Haven peninsula, Dorset not found on the Isles of Scilly. Old, unconfirmed records are also given; asterisks indicate species found on Scilly. No species occurs on Sark that is not known from Scilly.

	Alderney	Lundy	SHP		Alderney
Snails					old, unconfirmed
<i>Pupilla muscorum</i>	1			*	<i>Ponentina subvirescens</i>
<i>Vallonia costata</i>	1				
<i>Vallonia pulchella</i>			1		Lundy
<i>Acanthinula aculeata</i>			1		old, unconfirmed
<i>Ena obscura</i>			1		<i>Vertigo substriata</i>
<i>Punctum pygmaeum</i>		1	1		<i>Acanthinula aculeata</i>
<i>Vitrea crystallina</i>	1	1	1		
<i>Aegopinella pura</i>		1	1		South Haven Peninsula
<i>Oxychilus helveticus</i>	1		1		old, unconfirmed
<i>Monacha cantiana</i>			1		<i>Vertigo antivertigo</i>
<i>Trichia plebeia</i>	1				<i>Ceciloides acicula</i>
<i>Theba pisana</i>	1			*	<i>Balea perversa</i>
<i>Cepaea hortensis</i>	1	1	1		
Total 13	7	4	9	*	<i>Arion hortensis</i> agg.
Slugs				*	<i>Deroceras reticulatum</i>
<i>Arion silvaticus</i>	1	1			
Total 1	1	1	0		
Overall total 14	8	5	9		

including *Euconulus*, this difference is highly significant ( $\chi^2_1 = 27.1$ ,  $P < 0.001$ ). Inspection of the Atlas shows that some rare species are confined to the east of the County (e.g. *C. laminata*, *P. major*, *V. substriata*).

Table 5 shows the results of estimating the expected number of species on individual Scilly islands, on Scilly in aggregate, and for the other areas considered above. The estimates are based on the uncorrected (“Suffolk”) logarithmic species/area regression for all Britain, and on the corrected value allowing for latitude (Cameron, 2002 a). Allowing for under-recording on Sark (see above), the deviations from the corrected estimate are small for the larger islands, the mainland peninsula, and for Cornwall as a whole. Although the differences are slight, it is worth noting that while St Mary’s is slightly richer than expected, Cornwall as a whole is slightly poorer. The smaller islands, however, including Tresco, are substantially poorer than expected from mainland regressions.

DISCUSSION

In terms of species richness, the land mollusc fauna of St. Mary’s, as of Scilly as a whole, is the same size as would be expected if it were an equal-sized area of the British mainland. In this respect, it resembles the faunas of other islands around the British and

TABLE 4

Species recorded in Cornwall, but not on Scilly. Asterisks indicate rare species recorded in less than ten tetrads within the county

Woodland	Wetland
* <i>Acicula fusca</i>	* <i>Succinea putris</i>
<i>Acanthinula aculeata</i>	* <i>Vertigo antivertigo</i>
* <i>Ena obscura</i>	* <i>Vertigo substriata</i>
* <i>Phenacolimax major</i>	* <i>Vertigo moulinsiana</i>
<i>Aegopinella pura</i>	* <i>Vallonia pulchella</i>
* <i>Limax cinereoniger</i>	Miscellaneous
* <i>Cochlodina laminata</i>	* <i>Columella edentula</i>
<i>Perforatella subrufescens</i>	<i>Punctum pygmaeum</i>
* <i>Spermodea lamellata</i>	* <i>Paralaoma caputspinulae</i>
	* <i>Arion lusitanicus</i>
Calcicoles	* <i>Arion silvaticus</i>
* <i>Pomatias elegans</i>	<i>Arion owenii</i>
* <i>Pyramidula rupestris</i>	<i>Vitrea crystallina</i>
* <i>Ceciloides acicula</i>	<i>Oxychilus helveticus</i>
<i>Theba pisana</i>	<i>Testacella maugei</i>
	* <i>Testacella scutulum</i>
Open, calcium-rich	* <i>Monacha cantiana</i>
* <i>Pupilla muscorum</i>	<i>Hygromia cinctella</i>
* <i>Vallonia costata</i>	<i>Arianta arbustorum</i>
<i>Helicella itala</i>	<i>Cepaea hortensis</i>

TABLE 5

Number of species recorded in each island and area considered, and the expected numbers based on the standard, "Suffolk", logarithmic species/area regression, and on the correction for latitude (Cameron, 2002 a). The % deviation is of the actual relative to the expected based on the corrected regression.

	Actual species	Suffolk Estimate	Corrected Estimate	% Deviation
All Scilly	51	46	50	+2
St. Mary's	48	41	45	+7
Tresco	31	38	44	-30
St. Agnes	26	35	38	-32
Bryher	21	35	38	-44
St. Martin's	20	37	40	-50
Sampson	18	31	34	-46
Annet	12	29	31	-62
Alderney	47	43	48	+2
Sark	26	41	46	-43
Lundy	47	40	42	+12
SHP	43	40	43	0
Cornwall	86	82	89	-3

N. French coasts (Cameron, 2002 a & b), especially when latitudinal variation in richness is allowed for. It is to be noted that an earlier survey of St. Mary's (Richards & Robson, 1926) came, hesitantly, to a similar conclusion, but without a formal consideration of species/area relationships.

These islands thus depart from the expectation that continental shelf islands will be poorer in species than equivalent areas of mainland, and will show a steeper slope in the species/area regression (Rosenzweig, 1995), an expectation confirmed by many studies, including some on land molluscs (Mylonas, 1984; Vardinoyannis, 1994; Triantis *et al.* 2003). This finding is particularly striking, given that most of the islands considered lack, or have very little of, the two most important habitat types for native molluscs: woodland and eutrophic wetland. The range of environments is limited, and on any consideration of both habitat/biocoenoses and area, these islands might be expected to be impoverished (e.g., the Choros model of Triantis *et al.* 2003).

Of the islands considered in Cameron (2002 a & b), all but one were inhabited by humans, and had areas of 4 km<sup>2</sup> or more. The exception, Flat Holm in the Bristol Channel (0.23 km<sup>2</sup>), was considerably poorer in species than expected, despite the presence of limestone. In retrospect, examination of the original data (Young and Evans, 1992) suggests that the survey did not sample slugs adequately, and is an underestimate.

In this study of Scilly, however, we have a number of smaller islands, both occupied and unoccupied by humans. Within Scilly, the species/area relationship appears much more like that expected from the majority of island studies elsewhere, both in the impoverishment of the faunas, and in the slope of the relationship. Given the small number of islands involved, the slopes generated will have large errors, but it is notable that the slope for slugs, in particular, is very steep relative to the norm for continental shelf islands (Rosenzweig, 1995). While the effect of differential sampling effort cannot be dismissed, the comparison of the fauna of St. Mary's with all other islands combined suggests that it is not the main cause of this different relationship.

In this case, we can extend the analysis by considering the composition, as well as the absolute richness of the fauna, beginning a species-based approach (Lomolino, 2000 a). In the regional context (Cornwall), it is common rather than rare species that are found on Scilly. The species common to all seven islands surveyed are also found on all other islands of similar character in the English Channel. Species with strong associations with woodland are generally absent. On the larger inhabited islands, the slug fauna is especially rich. Excluding the elusive and generally rare *Testacella* species, St. Mary's holds 16 of the 22 slugs recorded for Cornwall (73%), but only 32 of 62 snails (52%). For Tresco, the disparity is even greater: 55% of slugs, but only 31% of the snails. Despite its small human population, Tresco has a substantial trade in horticulture. These ratios can be contrasted with those on the South Haven Peninsula, similar in area to St. Mary's, where there is virtually no agriculture or horticulture (Cameron, 2001): 35 snails, but only 8 slugs. By contrast, Alderney and Lundy resemble St. Mary's.

The faunal richness of islands, excluding evolution *in situ*, is determined by the rate of immigration and by persistence (the inverse of the probability of extinction). Given that these islands were all at some time joined to the mainland, persistence is a better term to use. It cannot be assumed that these processes are in balance, so that the faunas are in equilibrium (Lomolino, 2000 a; Lomolino and Weiser, 2001). In particular, there may be substantial and rapid shifts in habitats caused by human activities (Cameron *et al.*, 1998; Cameron, 2001).

In terms of persistence, the Isles of Scilly, as a whole, were isolated from the mainland in the early Flandrian (11,000 years ago), making it unlikely that a now common and widespread species such as *Cepaea nemoralis* could have reached them beforehand (Cameron *et al.* 1998). We have no mid-Flandrian faunas to help us determine long-term persistence; given their anthropophobic habits, it seems probable that *Leiostyla anglica*,



*Zonitoides excavatus* and *Ponentina subvirescens* are long term survivors. It is impossible at present to say which others are persistent, which natural colonisers and which introductions, deliberate or otherwise. Most other species of snail involved appear to have good powers of passive dispersal over sea, human-assisted or not. Species such as *Columella aspera*, *Cochlicopa lubrica*, *Balea perversa* and *Vitrea contracta* appear to be native to the oceanic archipelagos of Madeira or the Azores. Amongst other snails, we can only note that several species, for example *Oxychilus draparnaudi*, *Candidula intersecta*, *Cernuella virgata*, *Cochlicella acuta* and *Helix aspersa*, are known to be introductions to Britain (Kerney, 1999), and that others, such as *Oxychilus cellarius* and *Trichia striolata*, are often found in gardens.

The slugs, in general, leave no identifiable subfossil remains, and their history is usually obscure. Three slugs present on Scilly, *Boettgerilla pallens*, *Lehmannia valentiana* and *Deroceras panormitanum*, are very recent arrivals in Britain as a whole (Kerney, 1999). Most of the rest are found in horticultural or agricultural land, as well as in less disturbed places. The only anthropophobic species in Cornwall, *Limax cinereoniger*, is missing from all the islands considered here.

Comparing the extremes within Scilly, St. Mary's with Annet, we can see evidence both for differential survival and colonisation. St. Mary's is the stronghold of the relics of early woodland and wetland, and also hosts a mass of anthropochorous slugs; Annet has only the tolerant, widespread species amongst the snails, and a tiny slug fauna. The steepness of the between island species/area curve in Scilly appears to result both from differential persistence, probably related to the range and areas of habitats available, and to differential immigration related to human activity. While the latter is broadly related to the size of the human population, exceptional circumstances, such as the horticultural activity on Tresco, may distort it. Within Scilly, as in the Madeiran archipelago (L.M. Cook and R.A.D. Cameron, unpublished), size of island and human activity are strongly correlated, and this steepens the curve. Where the two are unconnected, as in the inhabited islands of the Aegean, human activity and the distribution of anthropochorous species flattens it (Mylonas, 1984).

In analysing the fauna of North Ronaldsay, Orkney (north of the Scottish mainland), Cameron (2002 b) found that the richest faunas were associated with artificial habitats around human settlement. A substantial proportion of the fauna was probably introduced. Conversely, while some species known in Scotland had perhaps failed to reach Orkney before it was isolated, it seemed likely that a number of absences reflected local extinction under the impact of human settlement. The Hebridean islands of Colonsay and Ulva, larger, less exploited, and retaining some woodland, hold many species with woodland affinities absent from all the smaller, cleared, islands considered here. There is some evidence of woodland cover on Scilly prior to the disintegration into smaller islands (Thomas, 1985), but we have no evidence as to extinctions.

Given the variety of factors that influence the richness and composition of these island faunas, the fit of the larger, inhabited ones to a mainland species/area curve may be fortuitous. While lacking the full woodland fauna, and in particular the restricted species that are rare even on the Cornish mainland, their coastal habitats add a number of species missing or uncommon in inland areas of Britain. It is noticeable that there is no sign of the "small island effect" (Lomolino and Weiser, 2001), where the species/area relationship breaks down due to the idiosyncratic habitat features of each island. Given the small areas needed to sustain viable molluscan populations, and the extensive human traffic, even smaller islands may be needed to detect such an effect. On the other hand, the disputed claim by Lomolino and colleagues that island species/area relationships may be sigmoid, and even asymptotic (Lomolino, 2000 b, Williamson, Gaston and Lonsdale, 2001) is given some credence, not because an asymptote is reached, but because islands above a certain size are, as it were, "mainlanded" by the

traffic of their human inhabitants, and therefore show a much shallower species/area slope in relation to each other, and to the mainland.

### ACKNOWLEDGEMENTS

We thank Dr. David Holyoak for helpful comments on the manuscript.

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# ABRALIOPSIS MORISII VS. ABRALIOPSIS PFEFFERI (CEPHALOPODA: ENOPLOTEUTHIDAE): WHICH IS THE RIGHT NAME?

GIAMBATTISTA BELLO<sup>1</sup>

*Abstract* Until the publication of the English translation of Kir Nesis' "Cephalopods of the World" (1987) the binomen *Abraliopsis morisii* (Vérany, 1839) had been universally used to indicate the only species of the genus known to live in the Mediterranean. Nesis' revision of the genus *Abraliopsis* dismissed the binomen *A. morisii* (Vérany, 1839) on the basis that within it there were included more than one species. Also, Nesis indicated that *Abraliopsis pfefferi* Joubin, 1896 was the only Mediterranean species and one of the two North Atlantic species. Despite it being impossible to examine Vérany's type specimen because of its probable loss, the re-examination of the original description of *A. morisii* (Vérany, 1839) is indeed sufficient to recognise its identity with *A. pfefferi* Joubin, 1896 and to distinguish it from the other North Atlantic *Abraliopsis* species, namely *A. atlantica* Nesis, 1982. Hence *A. morisii* (Vérany, 1839) is the valid binomen to indicate one of the two Atlantic species and the only Mediterranean species of *Abraliopsis*, whereas *A. pfefferi* Joubin, 1896 is just a junior synonym of the former and should not be used.

*Key words* Cephalopoda, Enoploteuthidae, Nomenclature, Mediterranean, Atlantic

## INTRODUCTION

The binomen *Abraliopsis morisii* (Vérany, 1839) (Cephalopoda: Enoploteuthidae) was used until 1987 to indicate the only Mediterranean species of *Abraliopsis*, a species also living in the Atlantic Ocean. Afterwards, it was dismissed on the basis that its original description may apply to more than one species (Nesis, 1987).

## HISTORY OF THE CASE

Vérany (1839) described the new species *Onychoteuthis morisii* on the basis of a specimen collected from the stomach contents of a common dolphin caught in the North-eastern Atlantic Ocean, 39°N 20°W (*i.e.* east of the Azores). The original description is fairly extensive for the standards of Vérany's time, and includes a colour plate with three drawings of the whole animal plus two figures of the gladius. The specimen described by Vérany (1839) without doubt belongs to the genus today known as *Abraliopsis* Joubin, 1896, despite no mention of the typical set of three photophores at the tip of both ventral arms (Naef, 1923). Incidentally, the photophores may have disappeared because of the dolphin digestive processes; photophores of this species come off easily in badly preserved specimens (author's personal observations). Vérany's description also mentions the dark-coloured buccal membrane – "La bouche est couronnée d'une membrane [...] d'une couleur brune noirâtre à angles blanchâtres." – and the length of the ventral arms – "la 4.<sup>me</sup> paire [de bras est] la plus longue et le double de la 1.<sup>re</sup> paire."; both characters are typical of *Abraliopsis*.

The species *Onychoteuthis morisii* Vérany, 1839 was accepted by subsequent authors: d'Orbigny (in Férussac & d'Orbigny, 1839) as *Enoploteuthis morisii*, Gray (1849) and Hoyle (1886) as *Abralia morrisii*.

Joubin (1896) described the new genus and species *Abraliopsis pfefferi* based on



a specimen collected in the western Mediterranean Sea, near Villefranche-sur-Mer (southern France). This specimen was seemingly the first of the genus *Abraliopsis*, as we understand it today, to be found in the Mediterranean. Joubin (1896) did not cite V  rany's (1839) paper nor his *Onychoteuthis morisii*.

Chun (1910) re-described and figured *Abraliopsis morisii* (V  rany, 1837 [sic!]). In his synonymy list Chun included the type specimens for two other species: *Enoploteuthis hoylei* Pfeffer, 1884 and *Abralia lineata* Goodrich, 1896. Chun lumped under the name *A. morisii* several adult and juvenile specimens from various Atlantic Ocean and various Indian Ocean sites. He also carried out an in depth discussion on the works of previous and contemporary authors on the genus *Abraliopsis*.

Pfeffer (1912) placed "*Abralia morrisii* (V  rany, 1837)" among the "Uncertain species of the genus *Abralia*". He interpreted V  rany (1839) somewhat superficially. He stated that the description and illustration of V  rany's species "leave no doubt that we are dealing with a generic relative of *Abralia hoylei*, *affinis* and *pfefferi*" (Pfeffer, 1912: 130). Nevertheless he concluded that "If the original specimen is no longer available, the species affiliation of *A. morrisii* cannot be established, unless one uses the locality of discovery to place it near *A. pfefferi*" (Pfeffer, 1912: 130). As for the locality of discovery he mistakenly added that the common dolphin in whose stomach V  rany's specimen was found had been "caught at 39   N., 20   E. [sic!] (longitude probably given as east of Paris)"; the geographical point indicated by Pfeffer (1912) is inland Greece. Indeed that dolphin was caught at 39  N 20  W [my underline], *i.e.* in the Atlantic Ocean.

Naef (1916, 1921, 1923) placed *Abraliopsis pfefferi* Joubin, 1896 into synonymy with *Abraliopsis morrisii*. Naef's (1923) description of *A. morisii* is very accurate. Following Naef (1923), the only Mediterranean *Abraliopsis* species has been universally ascribed to *A. morisii* (V  rany, 1839); *e.g.* Degner (1925), Mangold-Wirz (1963), Bello (1986).

Nesis (1982) observed that "Under the name *Abraliopsis morisii* there were included more than one species of *Abraliopsis*. It is impossible to determine which is the real *A. morisii* (V  rany, 1837) due to incomplete description. K. Chun (1910) mentioned under this name three species ..." [English translation from the original Russian text (Nesis, 1982), in Nesis (1987: 180)]. Consequently Nesis (1982) ascribed each of the three species figured in Chun (1910) to *Abraliopsis lineata* (Goodrich, 1896) from the tropical Indo-West Pacific from eastern Africa to Polynesia, *Abraliopsis chuni* n. sp. from the tropical Indo-West Pacific from eastern Africa to the Line Islands, and *Abraliopsis atlantica* n. sp. from the tropical and subtropical Atlantic, Caribbean Sea and Gulf of Mexico. Moreover Nesis (1982) considered *Abraliopsis pfefferi* Joubin, 1896 a subspecies of *Abraliopsis hoylei* (Pfeffer, 1884), found in the tropical and subtropical Atlantic Ocean, the Gulf of Mexico and the Mediterranean Sea.

The opinion of Nesis (1982) about *Abraliopsis morisii* (V  rany, 1839) became easily accessible to the world teuthologists thanks to the translation into English (Nesis, 1987) of Nesis' work from 1982. Afterwards, the binomen *Abraliopsis morisii* (V  rany, 1839) has gone progressively out of use, being substituted by *Abraliopsis pfefferi* Joubin, 1896 – or *Abraliopsis hoylei pfefferi* Joubin, 1896 – to indicate the only Mediterranean *Abraliopsis* species as well as the same species living in the Atlantic Ocean; *e.g.* Mangold & Boletzky

• The exact publication year of V  rany's paper is 1839. Chun (1910) and several subsequent authors, including Pfeffer (1912), mistakenly report 1837. Such an error is due to the fact that V  rany's (1839) paper on *Onychoteuthis morisii* was published jointly to another paper of the same author, titled "M  moire sur six nouvelles esp  ces de C  phalopodes trouv  s dans la M  diterran  e    Nice", that had been read in a 1837 meeting of the Reale Accademia delle Scienze di Torino, as stated just after the title: "Lu dans la s  ance du 26 f  vrier 1837". However both papers were published in 1839. The fact that many authors have reported an erroneous publication date as well as erroneous spellings of the specific name indicates, in my opinion, that they most probably did not view the original work by V  rany (1839), but rather relied on quotations of that paper by other authors.

(1987), Guerra (1992), Roeleveld (1998).

Young, Burgess, Roper, Sweeney & Stephen (1998), in their review of worldwide Enoploteuthidae, reported both *Abraliopsis pfefferi* Joubin, 1896 (geographical distribution: Mediterranean Sea, Northeast Atlantic, Northwest Atlantic, Indian Ocean) and *Abraliopsis morisii* (Vérany, 1839) (geographical distribution: Northeast Atlantic). Young *et al.* (1998) in commenting on the latter species, reported in detail Nesis' (1982) opinion and listed *Abraliopsis morisii* (Vérany, 1839) "among the valid species although its status is uncertain." However, Sweeney & Roper (1998) did not report *Abraliopsis morisii* (Vérany, 1839) in the overall list of the "Classification of the Currently Accepted Taxa of Recent Cephalopoda", which was published in the same volume as the Enoploteuthidae revision by Young *et al.* (1998). Also Tsuchiya's (2000) review of the genus *Abraliopsis* Joubin, 1896 does not list *Abraliopsis morisii* (Vérany, 1839); as for the Atlantic region this review only reports *Abraliopsis atlantica* Nesis, 1982 and *Abraliopsis pfefferi* Joubin, 1896. Lastly, Sweeney (2001) lists *A. morisii* among the taxa "whose validity has been questioned, but which currently require further study to be published either as a synonym or determined to be a valid species". The type locality listed therein should be corrected to 39°N, 20°W (Atlantic Ocean).

### TYPE SPECIMEN

The repository for the type specimen of *Abraliopsis morisii* (Vérany, 1839) was presumed to be the Muséum d'Histoire Naturelle de Nice (France) which holds Vérany's collections. Unfortunately the type specimen is not at the Nice Muséum (Chamagne Rollier, personal communication), nor it is kept at the Muséum National d'Histoire Naturelle in Paris (see negative evidence in Lu, Boucher-Rodoni & Tillier, 1995). This type specimen is probably lost.

### COMMENTS ON THE CASE

Nesis (1982) dismissed the binomen "*Abraliopsis morisii* (Vérany, 1839) *sensu* Chun (1910)" even though neither Nesis nor Chun examined the type of *A. morisii*. Such an action should not have involved the species *Abraliopsis morisii* as meant by Vérany (1839), a species which had been already aptly revised by Naef (1923) and who also had shown *Abraliopsis pfefferi* Joubin, 1896 to be a synonym of *Abraliopsis morisii* (Vérany, 1839). In other words, the matters of the validity of *Abraliopsis morisii* (Vérany, 1839), the synonymy of *Abraliopsis pfefferi* Joubin, 1896 with *Abraliopsis morisii* (Vérany, 1839), and the confusion brought forth by Chun (1910) had been already settled by Naef (1923).

The absence of a type specimen for *Abraliopsis morisii* (Vérany, 1839) does not allow for the resolution of the problem in a straightforward way. However the original description by Vérany (1839) is, in my opinion, sufficient to discriminate between the two North Atlantic *Abraliopsis* specific entities reported by Nesis (1982, 1987) and Tsuchiya (2000), namely *A. pfefferi* and *A. atlantica*.

The three life size drawings of *A. morisii* made by Vérany himself (Vérany, 1839: plate II) show the presence of hooks along the entire length of all the arms. This character is typical of *A. hoylei pfefferi* rather than *A. atlantica*: the former has "about 10 pairs of hooks on the 1st-3rd arms reaching almost to tips of arms", while the latter has "7-9 pairs of hooks and 5-10 pairs of suckers with denticulate rings on 1st-3rd arms" (Nesis, 1987: 179).

A second character that is in favour of the identity of *A. morisii* with *A. pfefferi* rather

than *A. atlantica* is the distribution of photophores (“points cromophères” in Vérany, 1839) on the head. Vérany (1839) wrote: “la région céphalique en est couverte [de points cromophères rougeâtres], sauf vert le centre ...”. The accurate drawing of the ventral side of the squid (Vérany, 1839: plate II) is in agreement with the description above. Contrary to this feature, *A. atlantica* displays a median row of photophores on the ventral side of head (Nesis, 1982, 1987). The identity of *A. morisii* with *A. pfefferi* is further supported by Tsuchiya’s (2000) statement that *A. pfefferi* is the only known species in the Atlantic among the species group having a scattered arrangement of integumental photophores on the ventral mantle and head.

Other characters, such as fin length and width, as measured by the present author on the dorsal drawing of the squid (Vérany, 1839: plate II) (see further), are ambiguous since they do not allow to ascribe that specimen to either *A. hoylei pfefferi* or *A. atlantica*. Measurements: ML = 38 mm; FL = 28.5 mm; FW = 33.5 mm; thence: FL index = 75% – according to Nesis (1987) this index is 75-80% in *A. hoylei pfefferi* and 60-67% in the subgenus *Micrabralia*, to which *A. atlantica* belongs; FW index = 88% – such an index is  $\geq 100\%$  in *A. hoylei pfefferi* and 75-90% in the subgenus *Micrabralia* (Nesis, 1987).

## CONCLUSIONS

To conclude, the description by Vérany (1839) of the species originally named *Onychoteuthis morisii* is in my opinion a valid description, further supported by the subsequent revision by Naef (1923). As a consequence of this, the binomen *Abraliopsis pfefferi* Joubin, 1896 is a junior synonym of Vérany’s species and should not be used. The name to be used to indicate the only *Abraliopsis* species known to live in the Mediterranean Sea and one of the two species known to live in the Atlantic Ocean is *Abraliopsis morisii* (Vérany, 1839) (as far as we presently know, the only other Atlantic species is *Abraliopsis atlantica* Nesis, 1982).

## ACKNOWLEDGEMENTS

I made the late Dr. Kir Nesis aware of my ideas about the nomenclatural problem of *Abraliopsis morisii* / *pfefferi* just a few months before he passed away. I am grateful to him for his kindness in discussing this topic with me and his willingness to review a manuscript when eventually completed. Dr. Nesis’ sudden death did not allow that to happen. I wish to warmly thank Brigitte Chamagne Rollier, Muséum d’Histoire Naturelle de Nice, for the information about Vérany’s type specimen, Richard E. Young for reading a previous version of this paper and offering helpful comments and suggestions, Mike Sweeney for critically reading and revising the manuscript, and two anonymous referees for their observations.

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# THE STATUS AND RELATIONSHIPS OF *VITRINA POLLONERIANA* FRA' PIERO, 1897, WITH DESCRIPTION OF *SARDOVITRINA* N. GEN. (GASTROPODA: PULMONATA: VITRINIDAE)

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*Abstract* *Vitrina polloneriana* Fra' Piero, 1897, is revised and assigned to the new monospecific genus: *Sardovitrina*. The new genus belongs to the plutoniine vitrinids (vitrinids with *glandula amatoria*) and is close to *Oligolimax* Fischer in Paulucci, 1878 (*Oligolimax* and *Sardovitrina* share a penial retractor passing above the right ommatophore retractor). However, all species included in *Oligolimax* are distinct from *Sardovitrina* by the fact that they can withdraw their body entirely into the shell, and by virtue of small shell lobes and completely different internal structures of the penial complex.

*Key words* *Sardovitrina* n. gen., *Sardovitrina polloneriana*, *Vitrinidae*, taxonomy, systematics, distribution, Sardinia.

## INTRODUCTION

*Vitrina polloneriana* Fra' Piero [Arbanasich], 1897, a vitrinid species described from Sardinia in the late 19th century, has never been re-examined since it was described. For this its generic allocation was only tentative: Alzona (1971) included it in the "Vitrinidae incertae sedis", Giusti & Castagnolo (1983) assigned it to *Phenacolimax* and Manganelli *et al.* (1995) attributed it to *Oligolimax*. Since *V. polloneriana* is a major endemic species of the Sardinian malacofauna, its revision was a priority.

The new detailed shell and anatomical study support the description of a new genus, *Sardovitrina*, for it. The relationships of *Sardovitrina* to other supraspecific taxa of the vitrinids will be the subject of another paper (Giusti & Manganelli, in preparation) in which all valid taxa of the genus-group of the vitrinids are redescribed and the systematics of the vitrinids is re-examined in detail.

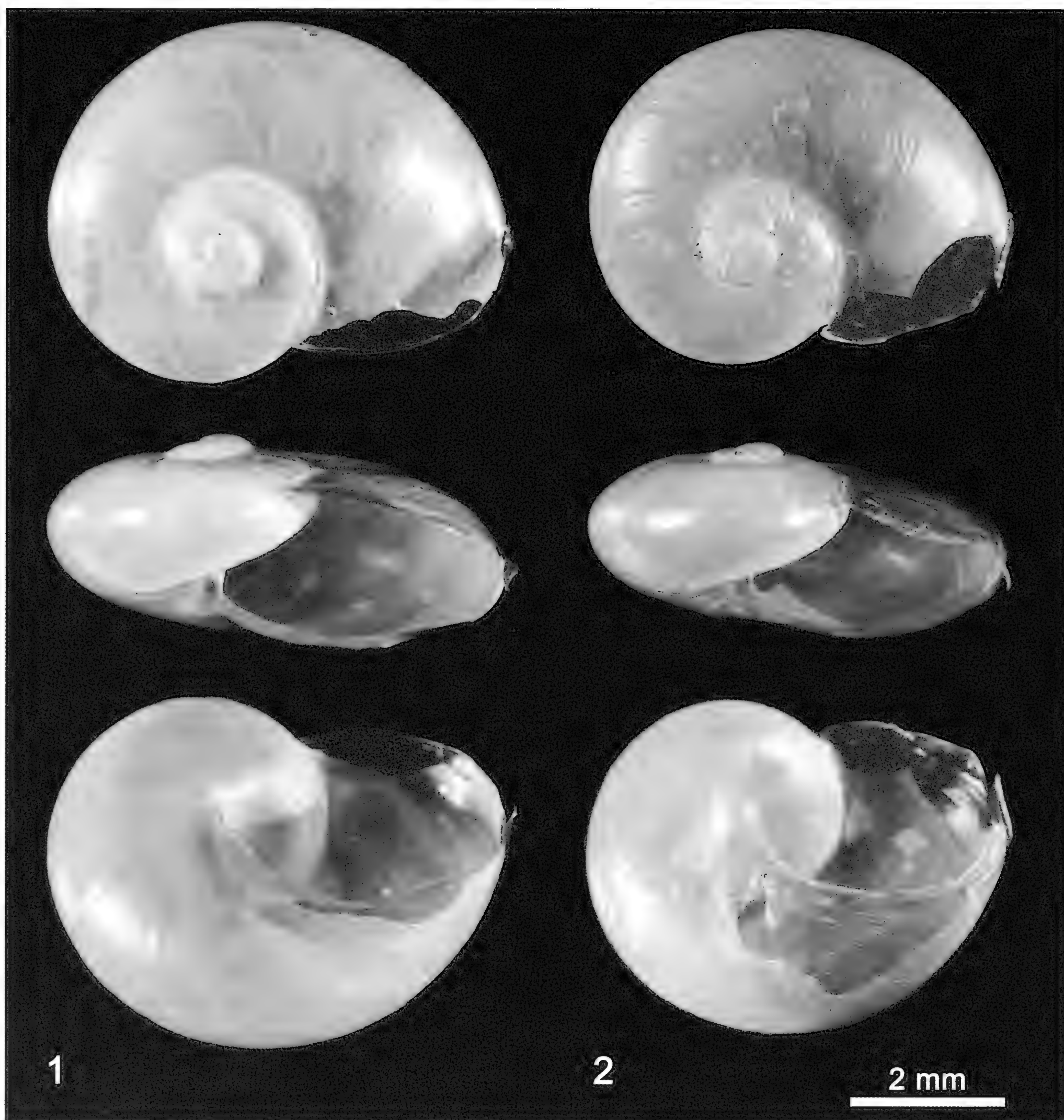
## MATERIAL AND METHODS

Shells were photographed under the light microscope (Wild M5A). Dimensions (shell height, shell diameter, aperture height and aperture diameter) were measured using calipers. Living specimens were drowned in water, then fixed and preserved in 75% ethanol buffered with NaHCO<sub>3</sub>. The bodies were isolated after crushing the shells and dissected under the light microscope (Wild M5A) using very fine pointed watchmaker's tweezers. Anatomical details were drawn using a Wild camera lucida. Shells and radulae, extracted manually from the buccal bulbs, were washed in pure 75% ethanol, mounted on copper blocks with electronconductive glue, sputter-coated with gold, and photographed using a Philips 505 SEM.

The material examined is listed as follows: locality, municipality and province names in parenthesis, UTM reference, collector(s), date, number of specimens and collection in which material is kept in parenthesis. Key to acronyms used in material examined: FGC, F. Giusti Collection (Dipartimento di Scienze Ambientali, Via Mattioli 4, 53100 Siena, Italy); MZUF, Museo Zoologico "La Specola", Sezione del Museo di Storia

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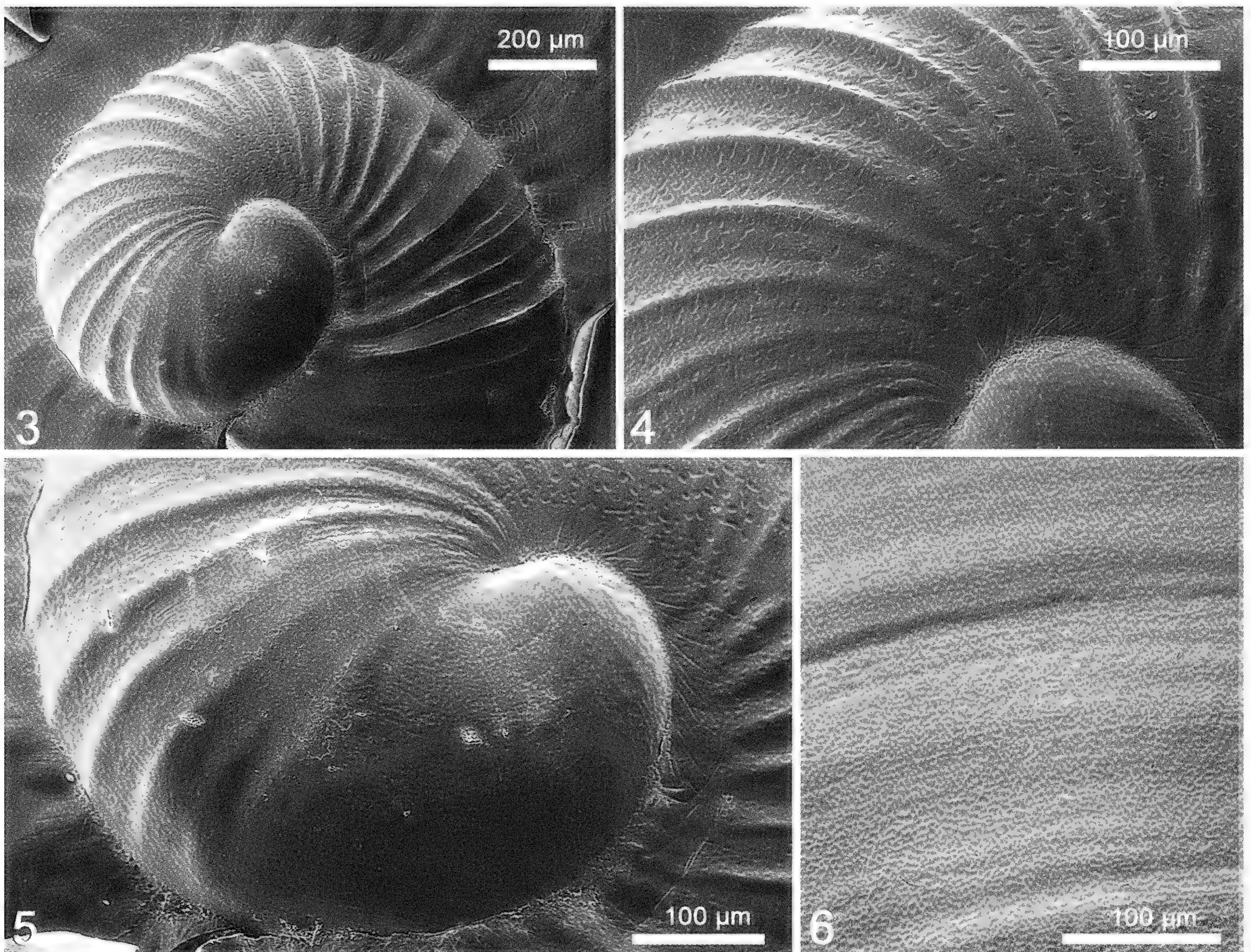


**Figs 1-2** Two shells of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 25.01.1972 (Fig. 1) and Arbatax (Tortolì, Nuoro), 32SNK62, J.A.J. Nienhuis leg. (Fig. 2).

Naturale dell'Università di Firenze (Via Romana 17, 50125 Firenze, Italy); MZUT, Museo Regionale di Scienze Naturali (Via G. Giolitti 36, 10123 Torino, Italy); SCC, S. Cianfanelli Collection (Piazzale Porta Romana 13, 50125 Firenze, Italy).

Key to acronyms used in Figs 7, 9-15: A, atrium; BC, bursa copulatrix; BW, body wall; DBC, duct of bursa copulatrix; EGL, external glandular layer; FO, free oviduct; GA, glandula amatoria; IGL, internal glandular layer; LDBL, left-dorsal body lobe; LSL, left shell lobe; PC, penial complex; PGA, papilla of glandula amatoria; PLS, papilla-like structure; POS, prostatic portion of ovispermiduct; PR, penial retractor muscle; RBL, right body lobe; RSL, right shell lobe; RTLS, rolled tongue-like structure; UOS, uterine portion of ovispermiduct; VD, vas deferens; VDO, vas deferens opening; VP, vaginal pleat; VW, vaginal walls.





**Figs 3-6** Detail of shell microsculpture of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 25.01.1972. Details of the protoconch (Figs 3-5) and teleoconch (Fig. 6).

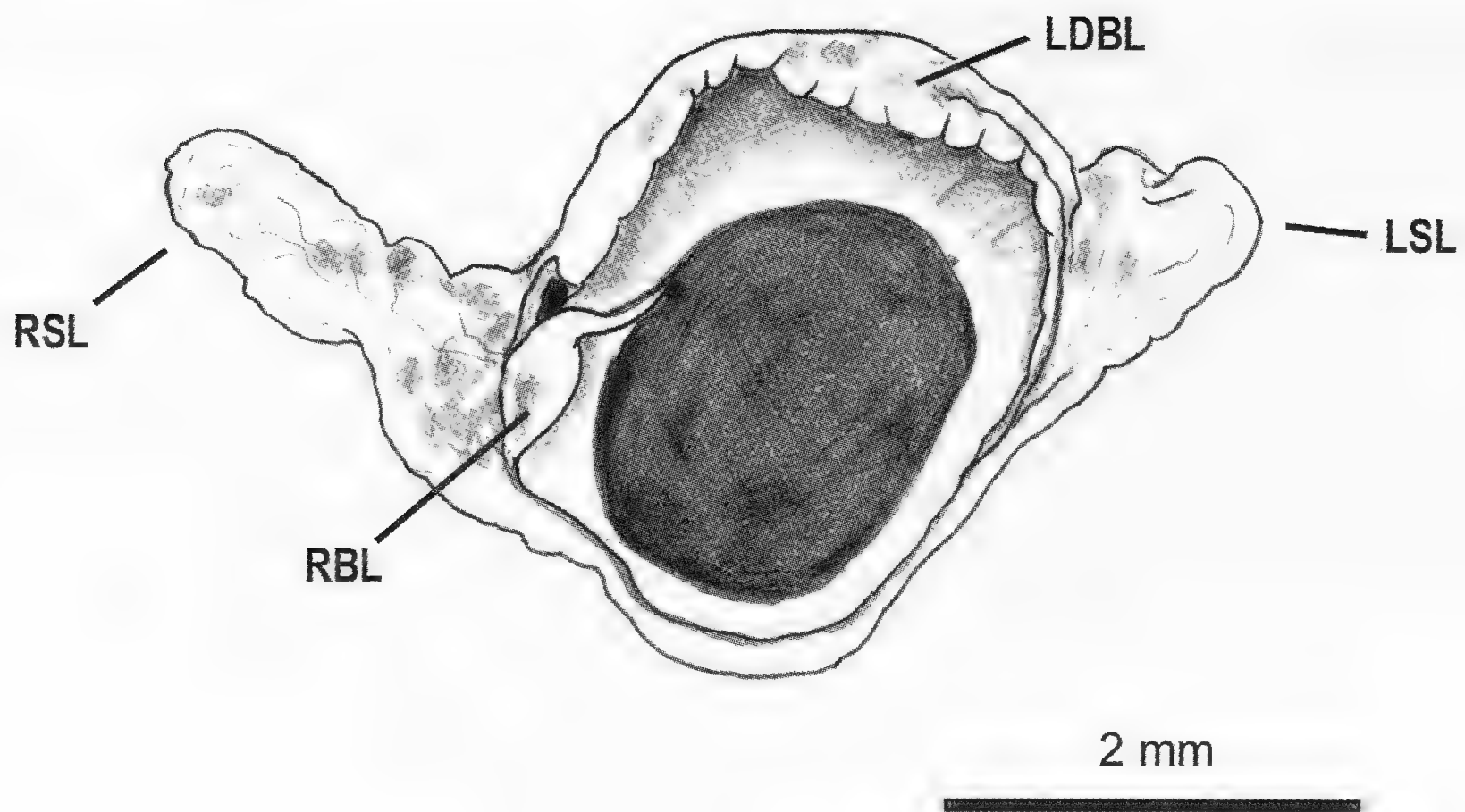
REVISION OF *VITRINA POLLONERIANA* FRA' PIERO [ARBANASICH], 1897, WITH  
DESCRIPTION OF *SARDOVITRINA* N. GEN.

*Sardovitrina* new genus

**Diagnosis** Semislug plutoniine vitrinid (vitrinids with glandula amatoria) characterized by: body which does not entirely withdraw inside shell; mantle border with well developed shell lobes (the right one longer and more slender than the left); protoconch with ribs and pits, but without periostracal crests; teleoconch more or less smooth; right ommatophore retractor free of penis and vagina; radula dichoglossan; glandula amatoria ("stimulator portion of vagina" or "vaginal stimulator") rather short, entering distal vagina through large, conical papilla; penial complex very small, without penial sheath, with penial gland consisting of slightly developed glandular tissue on side facing vagina; vas deferens rather short and wide, entering penial complex subapically and opening at tip of papilla-like structure, encircled by raised rolled tongue-like structure, basal margins of which are fused with base of papilla-like structure; penial retractor inserted apically – subapically on penial complex, passing over right ommatophore retractor and ending on diaphragm.

**Type species** *Vitrina polloneriana* Fra' Piero [Arbanasich], 1897





**Fig. 7** Mantle edge of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 11.01.1972.

*Derivation of name* From *sardus* -a -um, Sardinian, and *Vitrina*, the oldest established genus of the vitrinids.

***Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897)**

*Primary reference* *Vitrina polloneriana* Fra' Piero [Arbanasich], 1897: 70-71, 72, Pl. 2, Figs 2-4.

*Type material* Two syntypes are in the Pollonera collection, Museo Regionale di Scienze Naturali (see *historical material examined*).

*Type locality* Sardinia, "nel bosco di Marganai, uno dei più alti monti dell'Iglesiente".

*Historical material examined* "Dintorni di Iglesias", namely "nel bosco di Marganai, uno dei più alti monti dell'Iglesiente", Fra' Piero [Arbanasich] leg. 6.1896 (2 syntypes of *Vitrina polloneriana*, Pollonera collection [MZUT 123.1-2]; they consist of one adult shell with slightly broken aperture [MZUT 123.1] and one juvenile shell [MZUT 123.2]).

*Recent material examined* Arbatax (Tortolì, Nuoro), 32SNK62, 23.04.1983 (1 shell, MZUF 17996), J.A.J. Nienhuis leg. (7 spirit specimens [1 dissected], FGC), S. Cianfanelli & E. Talenti leg. 21.05.1993 (nn shells, SCC); Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 11.01.1972 (2 shells, FGC), J.A.J. Nienhuis leg. 25.01.1972 (10 spirit specimens [5 dissected], FGC).

*Diagnosis* As *Vitrina polloneriana* is the only known species of the genus *Sardovitrina*, see diagnosis of the genus.

*Description* Shell (Figs 1-6) dextral, from very small to small, very depressed, discoidal in profile, very thin and fragile, translucent and glossy, yellowish in colour when fresh, consisting of  $2\frac{11}{12}$  -  $3\frac{1}{8}$ , rather rapidly growing whorls; last whorl large, dilated, slightly descending, convex and never angled at periphery; sutures superficial, with



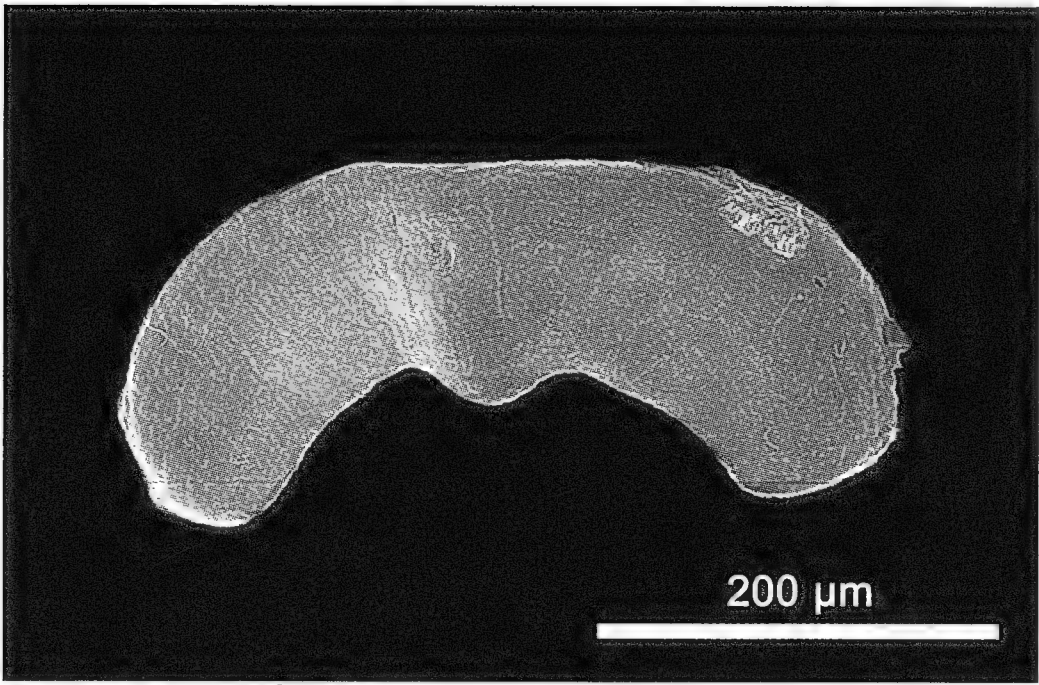


Fig. 8 Jaw of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Arbatax (Tortoli, Nuoro), 32SNK62, J.A.J. Nienhuis leg.

slightly wavy contour (due to ribs or growth lines); surface of protoconch (border between protoconch and teleoconch not evident but, possibly at about  $1\frac{1}{4}$  whorls) with well marked radial, rather regularly spaced ribs and irregular longitudinal rows of very small pits, fused at intervals to form fine, short, longitudinal furrows (pits and furrows are carved on surface of mineralized part of shell and not concealed by thin periostracum); surface of upper side of initial teleoconch with sculpture similar to that on protoconch, but with ribs more widely spaced, diminishing in size, and longitudinal rows of less closely spaced

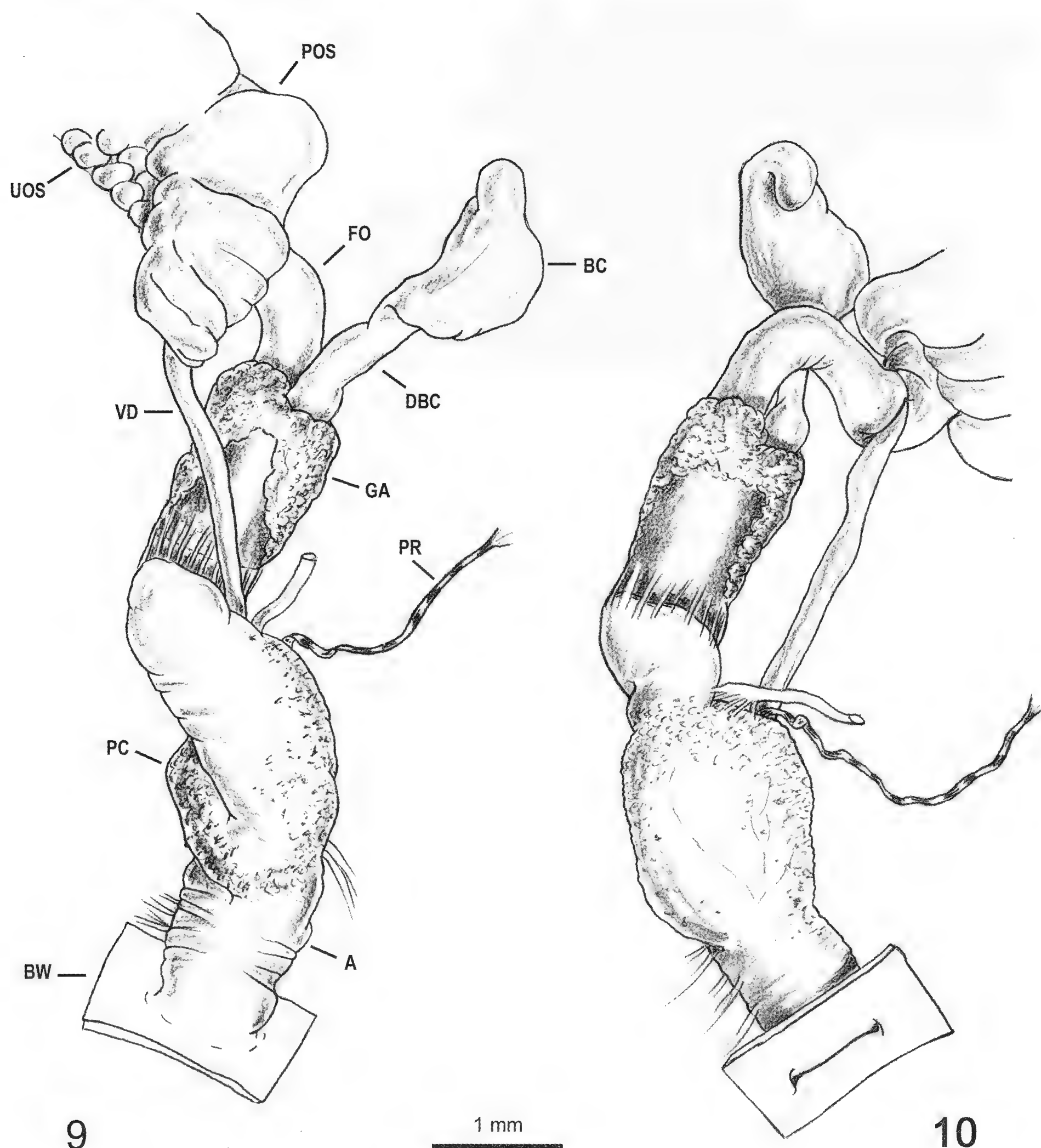
pits; after  $1\frac{1}{2}$  whorls, teleoconch rather smooth, without pits and with slightly raised, irregularly spaced growth lines; at high magnification, very fine radial striae are visible between two contiguous growth lines, while very fine, longitudinal striae are visible over entire surface (this kind of microsculpture of periostracum surface seems formed by longitudinal lines of very small pits on surface of underlying mineralized portion of shell); surface of final portion of last whorl rather smooth, with growth lines progressively sparser and less evident; surface of lower side of shell smooth especially around umbilicus; aperture wide (maximum diameter more than  $\frac{1}{2}$  of that of shell), oblique, oval; peristome incomplete, simple, its columellar margin vertical, bordered by thin periostracal membrane (aperture membrane) and upper and lower peristomal vertices joined by very thin, whitish parietal callosity; umbilicus very small, slit-like, partly covered by periostracal membrane bordering peristome.

Body and anatomical characters (Figs 7-8): body does not withdraw entirely into shell; body cream with sparse brown-black spots, mantle, mantle border and lobes with brown-black spots, and lateral parts of sole faintly pigmented; mantle border with right and left shell lobes and right and left-dorsal body lobes; right shell lobe longer and more slender than left; left-dorsal body lobe long, forming sort of calotte over neck and narrow process above pneumostome; right body lobe triangular, its smaller side bordering lower side of pneumostome. Foot aulacopod, with tripartite sole; central part tapering and ending before posterior tip of foot; lateral parts of sole fusing at posterior tip of foot; posterior tip of foot sharply pointed, dorsally keeled,

TABLE 1

Shell dimensions of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897).

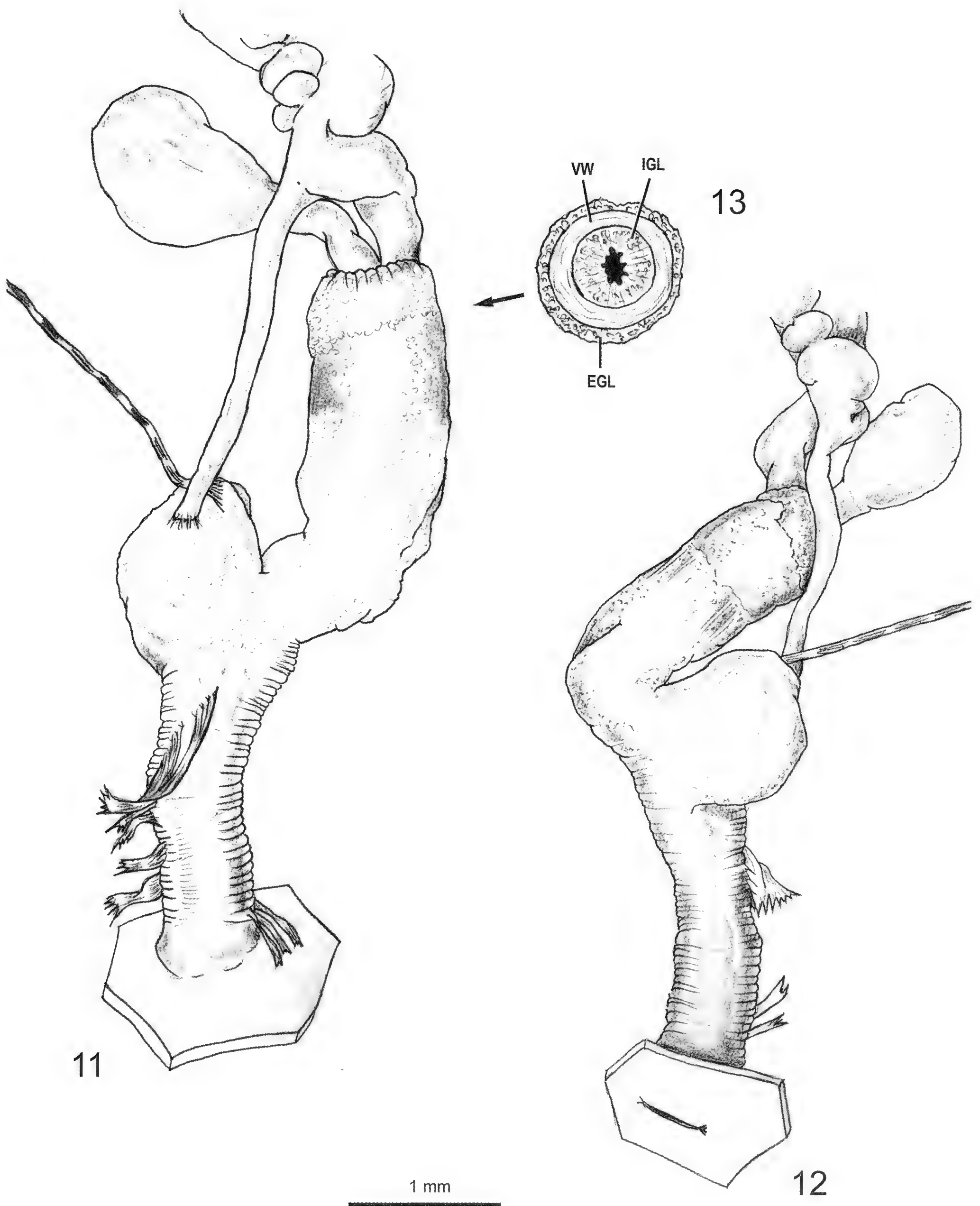
	shell height	shell diameter	aperture diameter	number of whorls	number of specimens
Arbatax (FGC)	2.4 – 2.6 mm	5.18 – 5.4 mm		$2\frac{3}{4}$	2
Arbatax (SCC)	2.4 – 2.9 mm	4.7 – 5.7 mm	2.8 – 3.4 mm	$2\frac{11}{12} - 3\frac{1}{8}$	7
Arbatax (MZUF 17996)	2.2 mm	4.4 mm	2.7 mm	$2\frac{3}{4}$	1
Iglesias (MZUT 123.1)	2.5 mm	4.2 mm	2.9 mm	$2\frac{10}{12}$	1
Lanusei (FGC)	2.2 – 3.0 mm	4.7 – 5.9 mm		$2\frac{11}{12} - 3$	5



**Figs 9-10** Distal genitalia of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Arbatax (Tortolì, Nuoro), 32SNK62, J.A.J. Nienhuis leg.

without caudal apparatus; sygmurethrous kidney; jaw oxygnathous (Fig. 8); right ommatophore retractor free of penis and vagina, running left of penis and below penial retractor; pedal penial innervation.

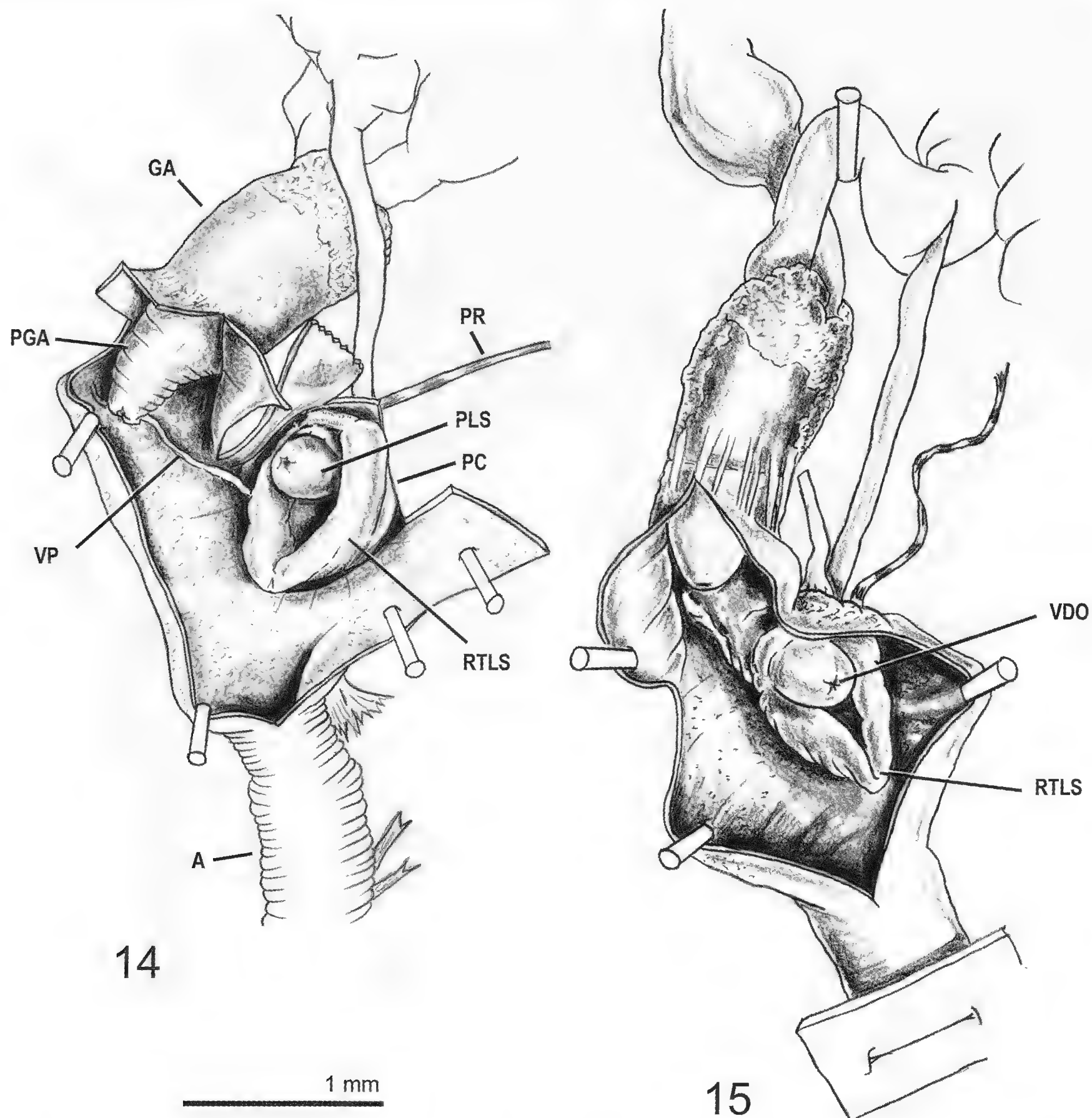
Genitalia (6 specimens examined) (Figs 9-15): first hermaphrodite duct blackish, ending at base of small, sac-like talon; albumen gland large, square, bilobate; ovispermiduct tightly coiled on itself. Bursa copulatrix large with duct wide and as long as bursa copulatrix; base of duct of bursa copulatrix and terminal part of free oviduct concealed by external glandular layer of glandula amatoria. Proximal vagina consisting of rather short and not particularly wide glandula amatoria. Glandula amatoria cylindrical with thick muscular walls, externally covered by rather thin glandular layer only in its proximal portion, and internally completely covered by rather thick glandular layer delimiting narrow lumen; distally, containing large conical papilla open at tip, protruding into



**Figs 11-13** Distal genitalia (Figs 11-12) and section of glandula amatoria (Fig. 13) of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 11.01.1972.

distal vagina. Distal vagina with very thin, subtransparent walls with sparse glandular tissue; internal walls smooth, with only one very thin pleat which starts from not very evident pad situated level with apex of papilla of glandula amatoria, continues into





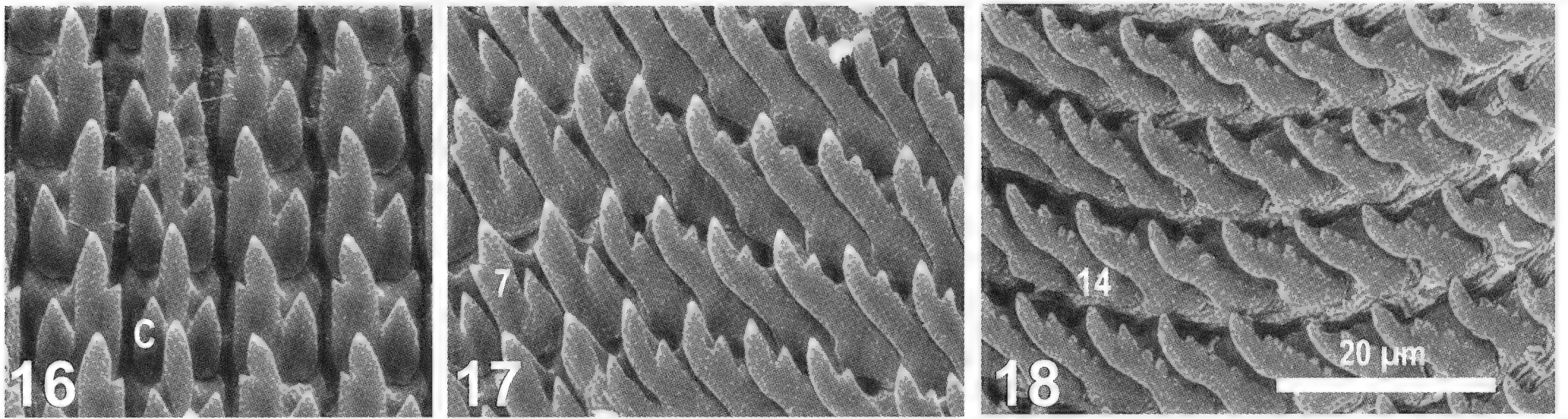
**Figs 14-15** Internal structure of penis and vagina of specimens of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 11.01.1972 (Fig. 14) and Arbatax (Tortoli, Nuoro), 32SNK62, J.A.J. Nienhuis leg. (Fig. 15).

penis and fuses with base of penial rolled tongue-like structure (see below). Penial complex very short, globular (sometimes so short as to seem simple outgrowth of distal vagina) without penial sheath and covered by relatively undeveloped penial gland. Vas deferens very short and thick, entering penial complex subapically near insertion of rather short, slender penial retractor muscle. Internally, penial complex includes two structures: one rolled tongue-like and one papilla-like; rolled tongue-like structure is probably a markedly modified glandular roll, being situated in correspondence with external penial gland and embracing a well distinct, cylindrical papilla-like structure, at tip of which vas deferens opens into penial complex. Internal surface of penial complex smooth.

Genital atrium rather long, with traces of glandular acini on proximal part and muscular bands on its distal part.

Relationships between the right ommatophore retractor and distal genitalia similar in juveniles and adults. Penial retractor passes above right ommatophore retractor.

Radula (2 specimens examined) (Figs 16-18) consisting of many rows, each of 41-47 teeth, according to formula 2-3/1 + 11-12/2-5 + 7-8/3+ C/3 + 7-8/3 + 11-12/2-5 + 2-



**Figs 16-18** Radula of a specimen of *Sardovitrina polloneriana* (Fra' Piero [Arbanasich], 1897) from Lanusei (Lanusei, Nuoro), 32TNK41, J.A.J. Nienhuis leg. 25.01.1972 (C, central tooth).

3/1. Central teeth with robust basal plate having pointed upper vertices and tricuspid crown consisting of long mesocone and very short pointed ecto- and endocone. Lateral teeth with robust basal plate having outer pointed upper vertex and tricuspid crown consisting of very large mesocone, small endocone (at 2/3 of mesocone length) and small pointed ectocone. Marginal teeth with basal plate having bicuspid crown consisting of progressively more slender, inwardly curved mesocone and very small ectocone at half mesocone length; some marginal teeth, particularly among the more marginal ones with endocone split into 2-5 small points (in which case outer side of mesocone is jagged). Extreme marginal teeth very reduced with crown monocuspid and thorn-like.

*Derivation of name* Named after Carlo Pollonera (1849–1923), Italian malacologist and painter (Colosi, 1923).

*Geographical distribution* Endemic to Sardinia.

## DISCUSSION

*Sardovitrina* n. gen. is immediately distinguished from *Eucobresia* Baker, 1929, *Semilimacella* Sóos, 1917, *Semilimax* Stabile, 1859, *Vitrina* Draparnaud, 1801, and *Vitrinobrachium* Künkel, 1929, because all these genera lack a glandula amatoria, although three of them have atrial (*Semilimacella* and *Semilimax*) or penial (*Vitrinobrachium*) accessory structures usually considered homologous (for *Eucobresia*, see: Forcart, 1944; Hausdorf, 2002; for *Semilimacella*, see: Targioni Tozzetti, 1873; Forcart, 1960; Rähle, 1980; for *Semilimax*, see: Hesse, 1923; Soós, 1924; Künkel, 1933; Forcart, 1956; Schileyko, 1986; Hausdorf, 2002; for *Vitrina*, see: Pilsbry, 1946; Forcart, 1955; Umiński, 1968; Schileyko, 1986; for *Vitrinobrachium*, see: Hesse, 1923; Künkel, 1933; Forcart, 1956; Giusti & Mazzini, 1971; Schileyko, 1986; Hausdorf, 2002).

All other vitrinid genera (*Arabivitrina* Thiele, 1931, *Canarivitrina* Valido & Alonso in Alonso *et al.*, 2000, *Guerrina* Odhner, 1954, *Insulivitrina* Hesse, 1923, *Madeirovitrina* Groh & Hemmen, 1986, *Oligolimax* Fischer in Paulucci, 1878, *Phenacolimax* Stabile, 1859, and *Plutonia* Stabile, 1864) have a glandula amatoria and are usually assigned to the pluto-niine vitrinids. Five of these taxa (*Canarivitrina*, *Guerrina*, *Insulivitrina*, *Madeirovitrina* and *Plutonia*) from the Macaronesian Islands are considered to belong to a monophyletic group and consequently are ranked as subgenera of a single genus: *Plutonia* (Alonso *et al.*, 2000; Bank *et al.*, 2001, 2002; Hausdorf, 2002), although there is little evidence to support this (Giusti & Manganelli, in preparation). Apart from the slug-like *Plutonia*, juvenile and adult specimens of all other Macaronesian genera have a penial retractor



TABLE 2

List of main characters of plutoniine vitrinids cited in the discussion. AP, accessory pilaster; BCR, bursa copulatrix retractor; GR, glandular roll; LC, laminar crest; MP, muscular pilaster; PC internal structures, penial complex internal structures: PR, penial retractor; PS, penial sheath; SL, shell lobes; RTLS, rolled tongue-like structure; VDO, vas deferens opening into penial complex; VDP, vas deferens papilla (question mark before the acronym indicates doubtful homology).

	habitus	SL	PR	PR	BCR	PS	VDO	PC internal structures
<i>Arabivitrina</i>	semislug	large	present	below ROR	absent	absent	subapical	GR lamellate, MP, AP
<i>Canarivitrina</i>	semislug	large	present	below ROR	absent	absent	medial	GR non-lamellate, LC, VDP
<i>Guerrina</i>	snail	small	present	below ROR	absent	absent	subapical	GR lamellate, MP
<i>Insulivitrina</i>	semislug	large	present	below ROR	absent	present	subapical	GR non-lamellate, ?MP, ?AP
<i>Madeirovitrina</i>	semislug	large	present	below ROR	present	absent	subapical	GR lamellate, MP, AP
<i>Oligolimax</i>	snail	small	present	above ROR	absent	absent	subapical	GR non-lamellate?, AP
<i>Phenacolimax</i>	semislug	large	present	below ROR	absent	present	subapical	GR lamellate, MP, AP
<i>Plutonia</i>	Slug	large	absent	—	present	absent	subapical	GR non-lamellate, ?AP
<i>Sardovitrina</i>	semislug	large	present	above ROR	absent	absent	subapical	VDP, RTLS

which passes below the right ommatophore retractor (*Plutonia* lacks a penial retractor). These genera are therefore immediately distinguishable from *Sardovitrina* which has a penial retractor which passes above the right ommatophore retractor. Moreover, none of them have such a reduced penial complex, though some species of *Madeirovitrina* and *Plutonia* have a short one. Finally, none of them have internal structures of penial complex similar to those of *Sardovitrina*. Species of *Canarivitrina*, *Guerrina* and *Madeirovitrina* usually have a glandular roll which is sometimes distally lamellate. Species of *Insulivitrina* and *Plutonia* have a longitudinal glandular structure possibly homologous with the glandular roll. *Canarivitrina* has a papilla, at the tip of which the vas deferens opens; the papilla is similar to that of *Sardovitrina*, but in a completely different position (for *Canarivitrina*, see: Alonso *et al.*, 2000; for *Guerrina*, see: Odhner, 1954; Ibáñez *et al.*, 1987; Valido *et al.*, 1993; for *Insulivitrina*, see: Schileyko, 1986; Alonso *et al.*, 1987; Ibáñez *et al.*, 1987; Morales *et al.*, 1988; Valido *et al.*, 1990; for *Madeirovitrina*, see: Odhner, 1937; Groh & Hemmen, 1986; for *Plutonia*, see: Wiktor & Backeljau, 1995).

*Arabivitrina* and *Phenacolimax* also have a penial retractor (and the penial complex) which passes below the right ommatophore retractor (though that of juveniles is different in length and position from that of adults). They also have a large penial complex and internal structure of penis completely different from that of *Sardovitrina*. Finally, *Phenacolimax* also has a penial sheath (for *Arabivitrina*, see: Hesse, 1923; Thiele, 1933; Hubendick, 1953; Forcart, 1957; Neubert, 1998; for *Phenacolimax*, see: Forcart, 1949; De Winter, 1990; Neubert, 1998).

Besides the glandula amatoria, *Oligolimax* also shares a penial retractor passing above the right ommatophore retractor with *Sardovitrina*. However, all species included in *Oligolimax* can withdraw into their shells, have small shell lobes and completely different internal structures of the penial complex (large glandular roll and slender accessory pilaster) (for *Oligolimax*, see: Forcart, 1959; Schileyko, 1986; Hausdorf, 1995, 2002; Manganelli & Giusti, 2004).

The differential analysis clearly reveals that *Sardovitrina* is distinct from the other plutoniine vitrinids. Among the plutoniine vitrinid genera, *Oligolimax* is certainly that closest to *Sardovitrina* (this was immediately evident after a first anatomical study which induced us to propose a tentative allocation of *Vitrina polloneriana* in *Oligolimax*; see Manganelli *et al.*, 1995). The new evidence on the structure of the penial complex (penial complex very small, penial gland slightly developed, glandular roll absent, papilla-like structure encircled by raised rolled tongue-like structure) obtained after more detailed anatomical study, together with the distinctive shell and body characters, strongly support a distinction.



Of the two options: *Sardovitrina* as a distinct genus and *Sardovitrina* as a subgenus of *Oligolimax*, we prefer the first. However, anatomical study of all the genus group taxa of the vitrinids is underway to check their distinctive morphological characters and to enable more refined phylogenetic analysis, similar to those by Alonso *et al.* (2000) and Hausdorf (2002), but including *Sardovitrina*. This study, which could provide new insights into vitrinid systematics, will be the subject of a future paper.

### ACKNOWLEDGMENTS

We thank Helen Ampt for revising the English, Simone Cianfanelli (Florence, Italy), Jos Nienhuis (Woltersum, The Netherlands) and Enrico Talenti (Florence, Italy) for field collection and Simone Cianfanelli (Florence, Italy) and Elena Gavetti (Turin, Italy) for information about or loan of material from their respective collections or museums.

Research financed by Siena University (PAR 2003, project "I molluschi non marini della fauna italiana: filogenesi, sistematica, faunistica, zoogeografia, conservazione").

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# THE GENUS *AXINUS* SOWERBY, 1821 IN THE MEDITERRANEAN BASIN (BIVALVIA: THYASIRIDAE)

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**Abstract** Deep-sea sampling in the Ionian Sea and NW off Mallorca (Mediterranean) has provided articulated and isolated valves of *Axinus grandis* (Verrill & Smith, 1885), an extant North Atlantic deep-sea bivalve. Some earlier records from the Mediterranean Sea have been described under the name *Halicardia ferruginea* Di Geronimo, 1974. *H. ferruginea* as well as *Mytilimeria fischeri* Locard, 1898 and *Mytilimeria saharica* Locard, 1898 are shown to be junior synonyms and are transferred from the family Verticordiidae to the family Thyasiridae. Our material is assigned to the Late Pliocene to Early Pleistocene based on the nannoplankton content of sediment infilling articulated shells. A study of the ontogenetic development of shell characters, feasible as investigated material includes specimens from different growth stages, shows a shift in the position of the ligament from internal in juveniles to partly external in adults. The genus *Axinus* Sowerby, 1821 is known stratigraphically from the Early Eocene until the Recent and geographically from the North Sea Basin, Atlantic, Mediterranean and Paratethys. Although little is known about the ecology of *Axinus* Sowerby, 1821, the examination of fossil as well as Recent occurrences suggests that *Axinus* is typically associated with deep-sea reducing, hydrogen sulphide-rich environments.

**Key words** Thyasiridae, *Axinus*, taxonomy, Mediterranean Sea, bathyal, Pliocene-Pleistocene

## INTRODUCTION

The first aim of this paper is to clarify the occurrence of *Axinus grandis* (Verrill & Smith, 1885) in the Mediterranean Basin recovered during various scientific cruises. Further aspects as those on the taxonomy and nomenclature as well as stratigraphy, distribution and ecology of this bivalve were also investigated.

The material was recovered during the CORAL mission ("Campagna Oceanografica Ricerca Ambiente *Lophelia*") which was primarily designed to study deep-sea environments of the Ionian Sea (Eastern Mediterranean), especially those of the deep-sea coral *Lophelia*. The expedition took place in August 2002 and was undertaken with the Italian research vessel *URANIA*. In one of the grab samples, an articulated shell of a thyasirid bivalve was encountered and identified as *Axinus grandis*, then unknown within the thyasirid fauna of the Mediterranean.

Two years later, in April 2004, during the COBAS mission ("Deep-water Corals of the Balears and Sardinia"), some additional valves and shell fragments of this peculiar species were dredged from the deep-sea NW off Mallorca (Western Mediterranean). This additional material allowed the investigation of the ontogenetic development of shell characters.

*Axinus* (as *Cryptodon*) *grandis* was described by Verrill & Smith in Verrill (1885: 436) from a living specimen and some valves collected during the ALBATROSS expedition of 1884 from the Atlantic Ocean off Delaware (East coast of the United States) at bathyal depth.

Figures in literature suggest that the species *Mytilimeria fischeri* Locard, 1898, *Mytilimeria saharica* Locard, 1898 and *Halicardia ferruginea* Di Geronimo, 1974 might

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be closely related or even identical with *Axinus grandis*. This is despite the fact that these taxa were referred to quite a different family and subclass of the Bivalvia, the Anomalodesmata. The type material of these species was subsequently examined in order to sort out this taxonomic confusion.

### GEOLOGICAL AGE ASSESSMENT

The sampled sites are swept by deep-sea currents, a phenomenon regularly observed in the Mediterranean, resulting in the winnowing and almost complete loss of modern sediments. Pleistocene deep-sea skeletal remains are thus not uncommon in the superficial Mediterranean deep-sea taphocoenoses. For age determination, the clay sediment infillings of articulated shells of both samples and hosting sediment were examined for their nannoplankton content. These investigations were due to the courtesy of Prof. Dr. Erlend Martini (January 2003 and May 2004, written reports).

The preservation state of the abundant calcareous nannoplankton of the COR2-76 sample is not optimal. The assemblage contains predominantly Cretaceous, Paleogene and Neogene reworked taxa. The occurrence of *Ceratolithus cristatus* Kamptner, 1950 points to an age not older than nannoplankton zone NN 18 (Late Pliocene) because this taxon has its first occurrence in the upper part of the *Discoaster brouweri* zone (NN 18; Martini 1971: 770). The concomitant absence of *Gephyrocapsa oceanica* Kamptner, 1943, having its first occurrence in the lower part of the *Pseudoemiliana lacunosa* zone (NN 19: Early Pleistocene; Martini 1971: 770), reasonably restricts the age of this sample to the Pliocene/Pleistocene transition.

From the COBAS-84 sample, the sediment of the rock dredge as well as the sediment infilling of one of the *Axinus* shells were investigated separately. Both subsamples contain the same nannoplankton association without autochthonous discoasterids. They include *Ceratolithus cristatus* Kamptner, 1950 and *Gephyrocapsa oceanica* Kamptner, 1943 as well as *Calcidiscus macintyreii* (Bukry & Bramlette, 1969) Loeblich & Tappan (1978) and therefore belong to the nannoplankton zone NN 19a (earliest Pleistocene).

### ABBREVIATIONS USED IN THE TEXT

**MCZ** = Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA

**MZB** = Museo di Zoologia, Università di Bologna, Italy

**SMF** = Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany

**MNHN** = Muséum national d'Histoire naturelle, Paris, France

**USNM** = United States National Museum of Natural History, Smithsonian Institution, Washington D.C., USA

**DSG** = Dipartimento di Scienze Geologiche, Università di Catania, Italy

**IGPUI** = Institute of Geology and Palaeontology, University of Innsbruck, Austria

**h** = height

**l** = length

**c** = convexity



## SYSTEMATICS

Class Bivalvia

Order Veneroida

Family Thyasiridae

Genus *Axinus* Sowerby, 1821Type species (by original designation) *Axinus angulatus* Sowerby, 1821

The genus *Axinus* was erected by James Sowerby (1821: 11, pl. 315) and based on *A. angulatus* described from the Eocene London Clay at Islington. He diagnosed the genus as “a free equalvalved, transverse, bivalve; anterior side very short; posterior side produced, truncated, with a lunette near the beaks: hinge with a long oblique ligament placed in a furrow. (...)” At the same time he regretted that there was very little possibility to discover the internal characteristics of the hinge, but he suspected that “(...) it has no teeth.” Furthermore “the shell appears to be thin, but I can trace neither the cicatrices of the muscles, nor of the edge of the mantle in the *angulatus*, which I consider the type of the genus. (...)” (Sowerby 1821: 11). Figure 1a shows the original illustration of the type species *Axinus angulatus* of J. Sowerby (1821, pl. 315).

Subsequently *Axinus* Sowerby, 1821 was not accepted in the literature and invariably regarded as a junior synonym of *Thyasira* Leach in Lamarck, 1818 (e.g., Cox et al., 1969; Abbott, 1974; Poppe & Goto, 1993).

Payne & Allen (1991), however, examined both fossil and living *Axinus* species and redefined the genus based upon the anatomical structure of the latter. Especial importance was given to the modification of the mantle edge “bearing sensory papillae and tentacles” (for details see Payne & Allen 1991: 483-486). Apart from the soft part morphology, this genus is characterized by a subquadrate to subpentagonal outline of the shell, and a sculpture of wave-like ridges, giving a typical crumpled appearance. Millard (2001) and Oliver & Killeen (2002) list *Axinus* as a valid genus within the family Thyasiridae, a status which is adopted by the present authors.

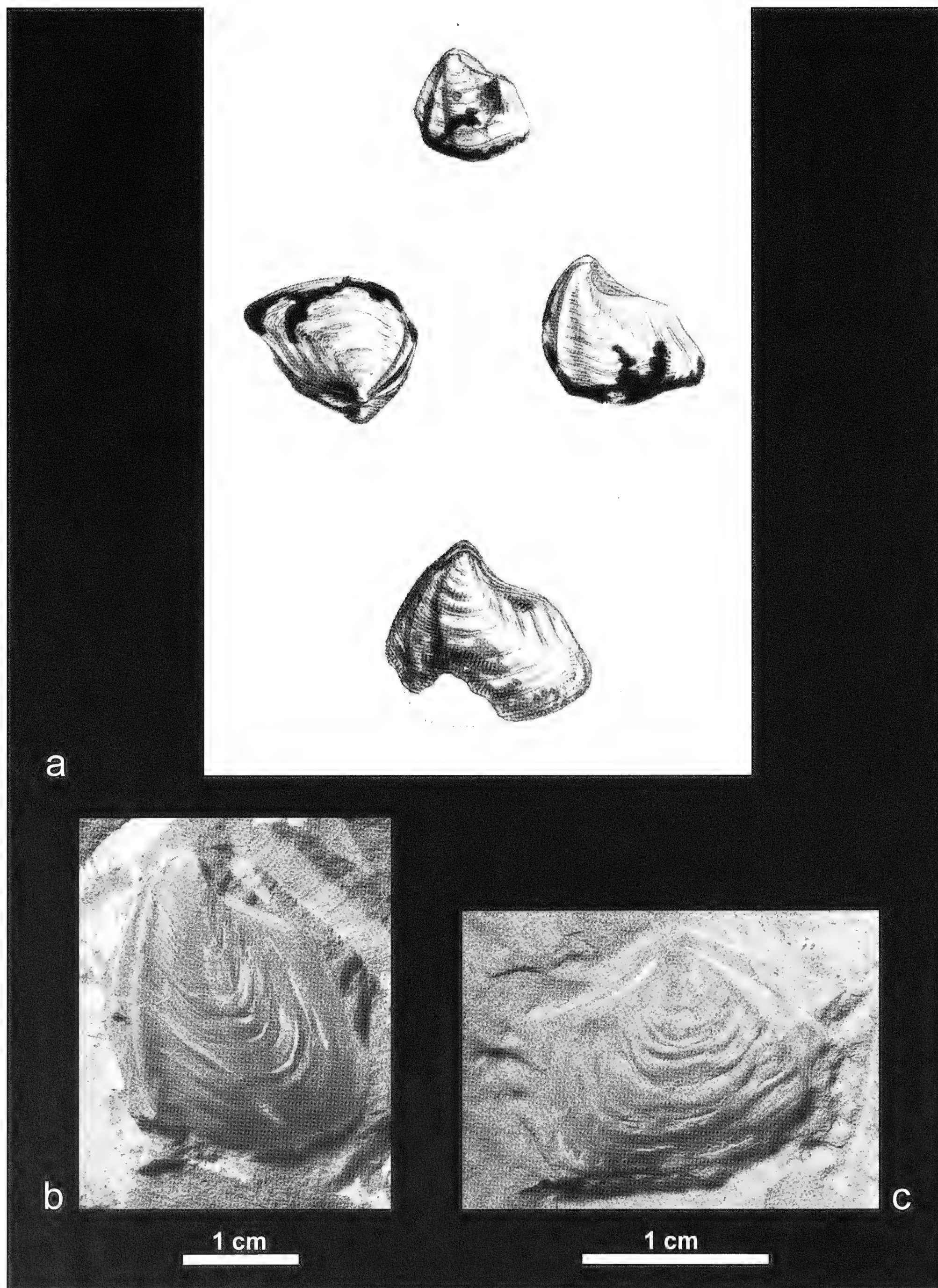
Referring to the fossil record, *Axinus* is known since at least the Paleogene. Representatives of the genus are *A. angulatus* Sowerby, 1821 from the Eocene London Clay (type species) and *A. varus* (Korobkov, 1939) from the Kiscellian (Early Oligocene) of the Paratethys (Figs. 1b-c; for detailed information see Löffler 1999: 133, herein however still ascribed to *Thyasira*).

*Axinus grandis* (Verrill & Smith in Verrill, 1885)

Figs. 2-5

- 1880 *Mytilimeria? Fischeri*, J. (MS.). - Jeffreys, p. 316 (**nom. nud.**)
- \*v 1885 *Cryptodon grandis* Verrill and Smith, sp. nov. - Verrill, p. 436, pl. 44, fig. 22
- 1886 *Cryptodon pyriformis*, n. s. - Dall, p. 267 (**syn. nov.**)
- 1889 *Cryptodon grandis* Verrill and Smith. - Dall, p. 50, pl. 46, fig. 22
- 1889 *Cryptodon pyriformis* Dall. - Dall, p. 50
- 1890 *Cryptodon pyriformis* Dall. - Dall, p. 263, pl. 14, fig. 1
- 1896 *Schizothærus grandis*, Verrill et Smith. - Locard, p. 180
- 1897 *Axinus pyriformis* Dall. - Dautzenberg & Fischer, p. 214
- v 1898 *Mytilimeria Fischeri*, Jeffreys. - Locard, p. 212, pl. 10, figs. 22-28 (**syn. nov.**)
- v 1898 *Mytilimeria Saharica*, Locard. - Locard, p. 213, pl. 10, figs. 29-31 (**syn. nov.**)
- 1898 *Schizothærus grandis*, Verrill et Smith. - Locard, p. 222





**Figure 1** Fossil species of *Axinus*; a) *Axinus angulatus* Sowerby, 1821 from the Eocene London Clay (type species of genus) original illustration of J. Sowerby (1821, pl. 315); b-c) *Axinus varus* (Korobkov, 1939) from the Kiscellian (Early Oligocene) of Bad Häring (Austria) of the Paratethys (Figures from Löffler, 1999), b: right valve (IGPUI: P.9691-Mi), c: left valve (IGPUI: F.5073)



- 1901 *Thyasira grandis* Verrill (as *Cryptodon*), 1885. - Dall, p. 785
- 1920 *Thyasira grandis* Verrill. - Lamy, p. 302
- 1927 *Thyasira grandis*, Verrill et Smith. - Dautzenberg, p. 313
- v 1974 *Halicardia ferruginea* n. sp. - Di Geronimo, p. 158, pl. 4, figs. 1-3 (syn. nov.)
- 1976 *Halicardia ferruginea* Di Geronimo. - Parenzan, p. 403, fig. 392
- 1991 *Axinus grandis* (Verrill & Smith, 1885). - Payne & Allen, p. 484, figs. 1-4; [here with a detailed synonymy list !]
- 1992 *Halicardia ferruginea* Di Geronimo, 1974. - Sabelli, Giannuzzi-Savelli & Bedulli, p. 101, 341, 492
- 1995 *Halicardia ferruginea* G. Di Geronimo, 1974. - Bedulli, Castagnolo, Ghisotti & Spada, p. 18
- 1995 *Halicardia ferruginea* Di Geronimo, 1974. - Bogi & Capua, p. 1, figs. 1-2

*Syntypes* "A large living specimen was taken at station 2,231, in 965 fathoms, N. lat. 38° 29', W. long. 73° 00'. Five valves, some of them nearly as large, were taken at station 2,228, in 1,582 fathoms. A small dead specimen (No. 35,757) was taken in 1883, at station 2,111, off Cape Hatteras, in 938 fathoms. (...)

Length of the largest specimen, 21 mm; height, from beak to ventral margin, 24 mm; breadth 15 mm. (...)." (Verrill & Smith in Verrill 1885: 436)

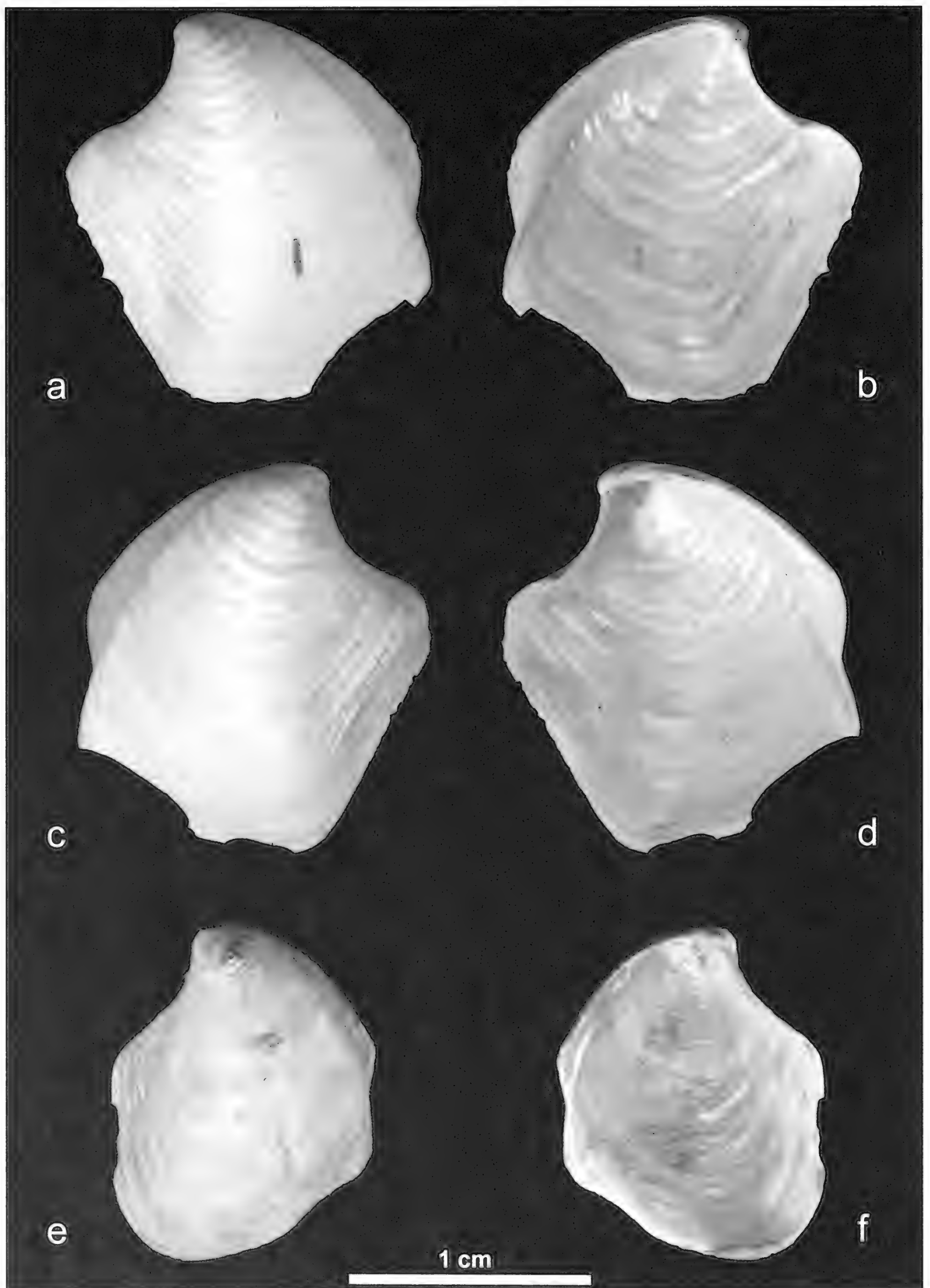
*Type locality* Northwest Atlantic off Delaware (N lat. 38° 29', W long. 73° 00'; station 2231) at 965 fathoms [= 1765 m] water depth [exploration by the steamer *ALBATROSS* in 1884]

*Original description* "Shell rather large, thick, angular, remarkably high, owing to the great prominence of the ventral margin and the elevation of the beaks, and with the surface strongly undulated by median and posterior folds. The beaks are high, acute and strongly incurved and turned forward. The lunule is large, cordate, sunken, and defined by a prominent ridge. The posterior dorsal margin has a long, narrow, fusiform ligamental area, bordered by a prominent, rounded ridge. Another larger and more prominent ridge extends from the beaks to the angle, leaving a sunken concave area behind it, and terminating in a prominence or lobe at the margin. Another broad and distinctly elevated, rounded ridge runs from the beak to the ventral margin, which projects downward in a prominent, rounded angle; this median ridge is divided into two parts by a slight furrow just behind the middle. Anteriorly there is a ridge, not very well marked, running from the beaks outside the lunular area and terminating in a rounded projection of the anterior margin. Thus the margin has an anterior and two posterior prominences, besides the great median lobe, while the anterior margin, in the lunular region, is strongly concave and the posterior dorsal margin is convex. The surface is dull grayish white, and closely covered with prominent and often sharply raised lines of growth, which are irregular and wavy or fibrous in appearance. The hinge-margin is thin, with a narrow, elongated ligamental groove, which is strengthened by a narrow buttress within; there are rudiments of teeth. (...)." (Verrill & Smith in Verrill 1885: 436)

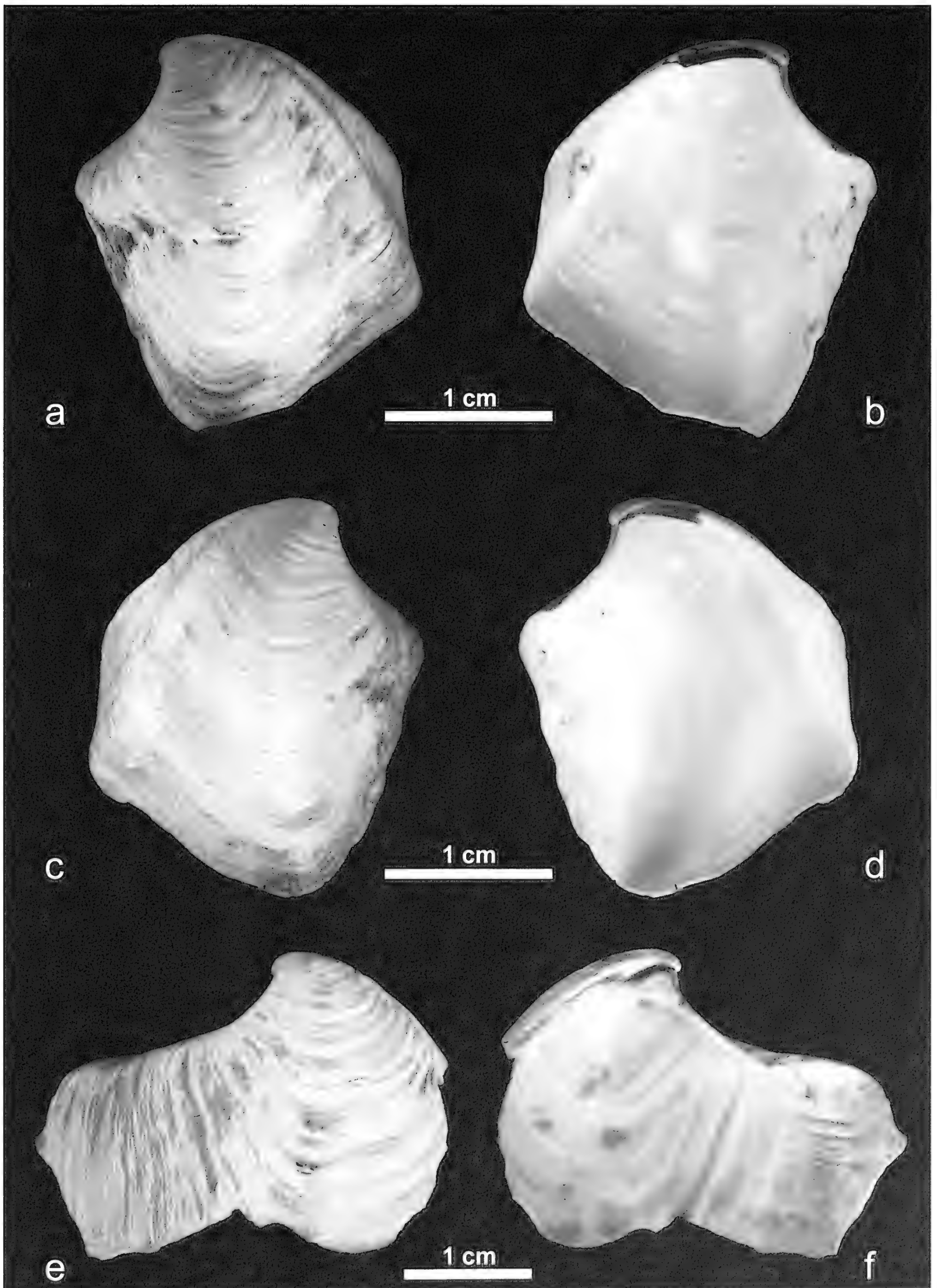
#### *Material examined and Measurements*

1) *Cryptodon grandis* Verrill & Smith, 1885; syntype, USNM, Cat. Nr. 44824; bivalved specimen: h = 23.7 mm, l = 18.2 mm. This specimen is labeled "Type" on the USNM label but merely should be regarded as syntype because it was not designated as holotype by Verrill & Smith. Payne & Allen (1991) erroneously indicated a "holotype" in the collection of MCZ at Harvard University. Figs. 3a-d.





**Figure 2** *Axinus grandis* (Verrill & Smith, 1885). (Photos courtesy of E. Neubert, SMF); a-b) left valve, COR2-76 (MZB: 43754); c-d) right valve of the same individual as Figs. 2a-b; e-f) holotype of *Halicardia ferruginea* Di Geronimo, left valve (DSG)



**Figure 3** *Axinus grandis* (Verrill & Smith, 1885). (Photos courtesy of E. Neubert, SMF); a-b) syntype of *Cryptodon grandis* Verrill & Smith, left valve (USNM: 44824); c-d) right valve of the same individual as Figs. 3a-b; e-f) holotype of *Mytilimeria saharica* Locard, left valve (MNHN)



2) *Mytilimeria fischeri* Locard, 1898; syntypes, MNHN; fragmentary left valve:  $h > 5.5$  mm, fragmentary right valve:  $h > 6.3$  mm, hingeless fragment left valve:  $h > 10.1$  mm; TRAVAILLEUR expedition 1880: Atlantic, North off Spain, dredge 4, depth 2651 m, Gulf of Gascogne, dredge 20, depth 1143 m. Note: material from both stations was found united within one tube. Figs. 4a-e.

3) *Mytilimeria saharica* Locard, 1898; holotype, MNHN; fragmentary left valve:  $h > 23.8$  mm; TALISMAN expedition 1883: Atlantic, West off the Sahara desert, dredge 93, depth 1495 m. Figs. 3e-f.

4) *Halicardia ferruginea* Di Geronimo, 1974; holotype (= Original to pl. 4, figs. 1-2), DSG, Collection I.P.C. n.5, left valve:  $h = 13.9$  mm,  $l = 11.2$  mm; fragmentary paratype (= Original to pl. 4, fig. 3), DSG, Collection I.P.C. n.5,  $h = 10.3$  mm; o/v RUTH ANN - November 1969: Ionian Sea, station R.A. 2 (Lat. N  $39^{\circ} 22' 24''$ , Long. E  $17^{\circ} 51' 06''$ ), depth 2300-2400 m. Figs. 2e-f, 5g.

#### *Newly collected material*

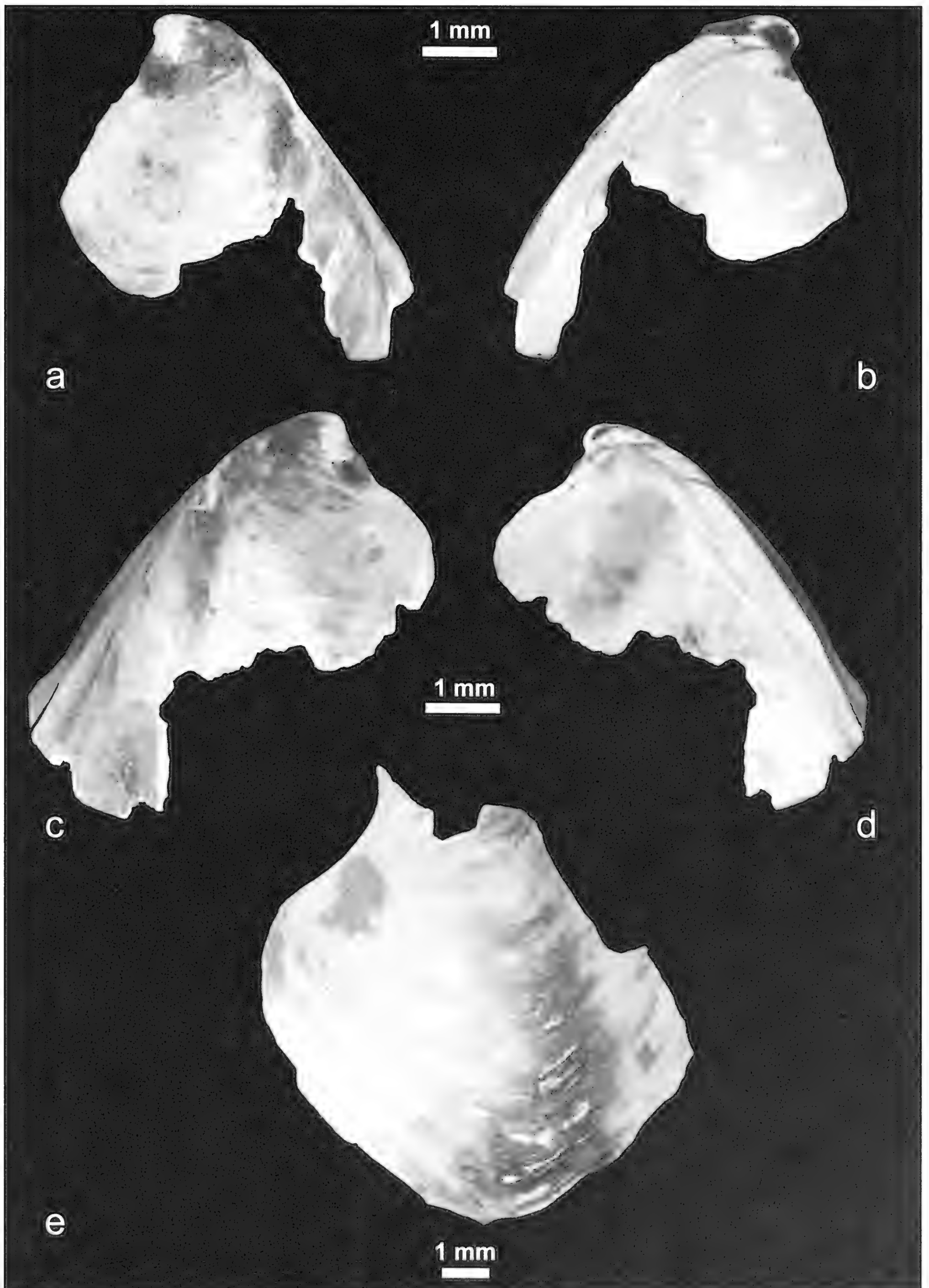
5) CORAL mission ("Campagna Oceanografica Ricerca Ambiente *Lophelia*") of the Italian RV URANIA: Mediterranean, western margin of the Ionian Sea, south off S<sup>ta</sup> Maria di Leuca; station COR2-76 (modified 65 l Van Veen grab), 23<sup>rd</sup> of August 2002;  $39^{\circ} 28.7492$  Lat N and  $18^{\circ} 22.6757$  Long E, at 788.40 m depth; from superficial clay sediment: one empty bivalved specimen in a good state of preservation:  $h = 16.2$  mm,  $l = 14.4$  mm,  $c = 4.7$  mm; stored at MZB, inventory number 43754. Figs. 2a-d, 5e, 5f.

6) COBAS mission ("Deep-water Corals of the Balears and Sardinia") of the Italian RV URANIA: Mediterranean, NW off Mallorca; station COBAS-84, 16<sup>th</sup> of April 2004; rock dredge, starting at  $39^{\circ} 53.6807$  Lat N and  $02^{\circ} 36.8396$  Long E at 612 m water depth and ending at  $39^{\circ} 53.1272$  Lat N and  $02^{\circ} 36.8458$  Long E at 347 m; from clay sediment: five isolated valves in a good state of preservation:  $h = 2.5-16.9$  mm,  $l = 2.2-13.1$  mm; 10 fragments of the hinge region; stored at MZB, inventory numbers 43755 and 43756 and SMF, inventory number 327919. Figs. 5a-d.

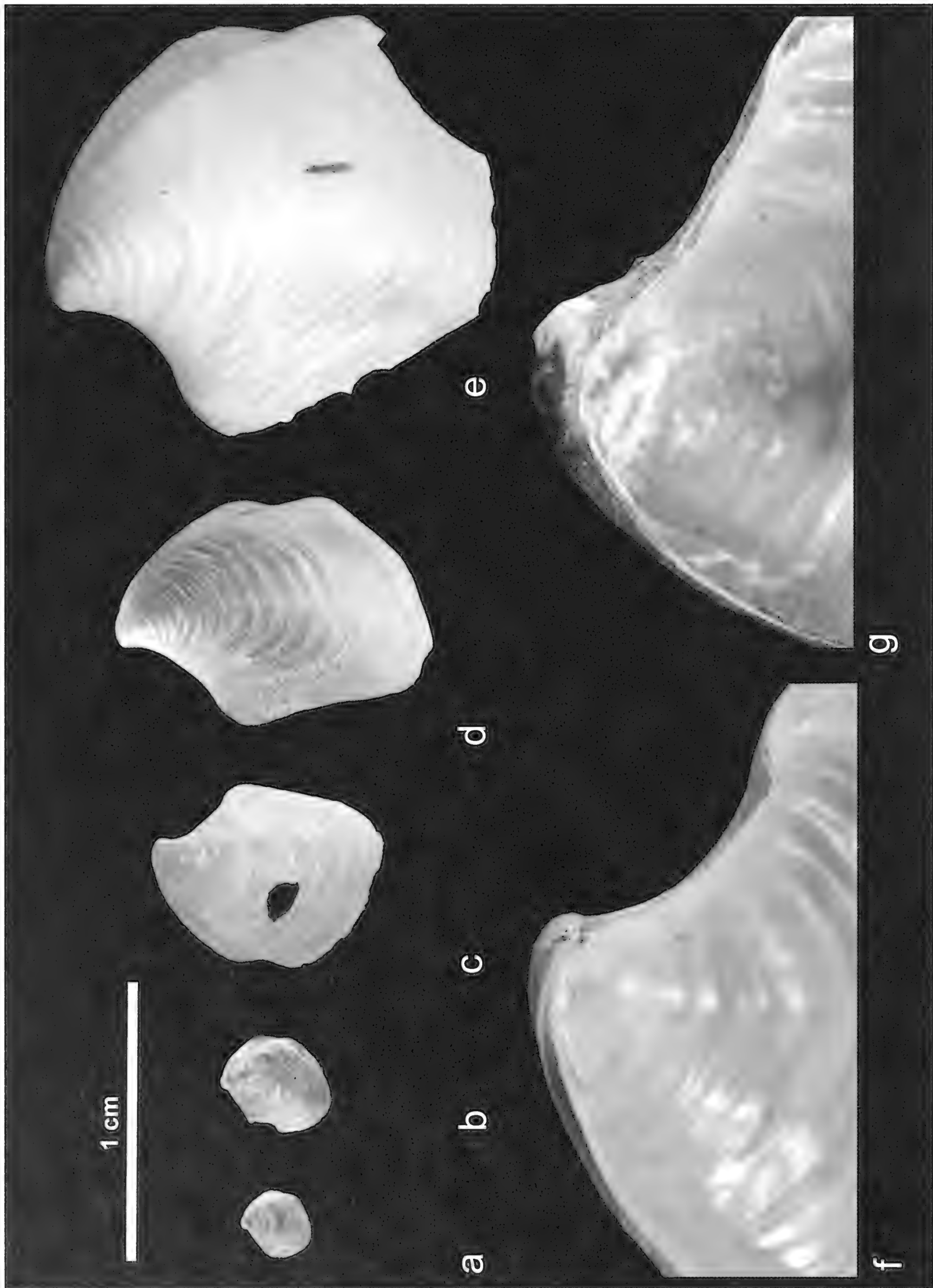
*Shell description* Shell thin and fragile, white, equivalved, markedly inequilateral, outline tending to be subquadrate; beaks small, pointed, prosogyrous, slightly coiled; prodissoconch not clearly demarcated; two characteristic ridges radiating from the beaks, the first less distinct running towards the edge dividing anterior and ventral margin, the second posterior, acute, nearly parallel to the posterior margin, running towards the border of ventral and posterior margins; dorsal margin divided by the beak into an anterior and a posterior part forming nearly a right angle, anterior dorsal part strongly concave, short, meeting the anterior margin in a right angle, posterior dorsal part convex, long, passing into the posterior margin in a shallow bent nearly forming a unit, posterior margin very short, slightly concave, meeting the ventral margin in an obtuse angle, ventral margin straight, passing into anterior margin in a right angle, anterior margin straight, as long as ventral margin; sculpture consisting of fine, closely spaced irregular and concentric grooves and ridges showing an undulated and crumpled appearance, grooves weakening towards the dorsal margin, growth lines well developed running parallel to the grooves; lunule well defined by an obtuse sulcus and clearly impressed.

Hinge edentulous, anterior hinge line developed as sharp ridge, in not fully grown specimens the hinge line is interrupted by a narrow notch at the junction with the posterior part, posterior hinge line also developed as sharp ridge starting from the beak, passing anterior hinge line and running along posterior margin, somewhat thickened solely at the posterior end of the ligament groove, in adult stage a somewhat thickened hinge plate is developed below the beak; ligament in juvenile respectively half grown specimens completely internal, resilifer respectively ligament groove elongate falciform,





**Figure 4** *Axinus grandis* (Verrill & Smith, 1885). (Photos courtesy of E. Neubert, SMF); a-e) syntypes of *Mytilimeria fischeri* Locard, (MNHN); a-b: fragmentary left valve; c-d: fragmentary right valve; e: hingeless fragment left valve



**Figure 5** *Axinus grandis* (Verrill & Smith, 1885). (Photos courtesy of E. Neubert, SMF); a-e) ontogenetic development; a-d: station COBAS-84 (MZB: 43755; SMF: 327919); e: station COR2-76 (MZB: 43754), same individual as Fig. 2a; f-g) hinge line, left valve; f: station COR2-76 (MZB: 43754), detail of Fig. 2b; g: holotype of *Halicardia ferruginea* Di Geronimo (DSG), detail of Fig. 2f

running from below the beak dorsally to 1/3 of dorsal margin, ornamented with fine transverse striation; in fully grown specimens ligament in its posterior part also partly external; anterior adductor muscle scar very small, below end of anterior hinge line oval, posterior adductor muscle scar small, beneath end of posterior hinge line moderately elongated.

## REMARKS

Dall (1886) described *Cryptodon pyriformis* from the Gulf of Mexico and the Caribbean Sea, which he himself (Dall, 1901) later on recognised as synonymous with *Thyasira grandis*.

*Mytilimeria fischeri* and *Mytilimeria saharica* were described from the East Atlantic Ocean by Locard (1898) within the family Verticordiidae Stoliczka, 1871. Actually *Mytilimeria* Conrad, 1837 is grouped within the family Lyonsiidae (e.g., Cox et al., 1969; Vaught, 1989; Millard, 2001). However, the most relevant shell characteristics for this family, especially the nacreous gloss on the inside as well as a typical granulation on the outside of the valves, are completely lacking in Locard's type material.

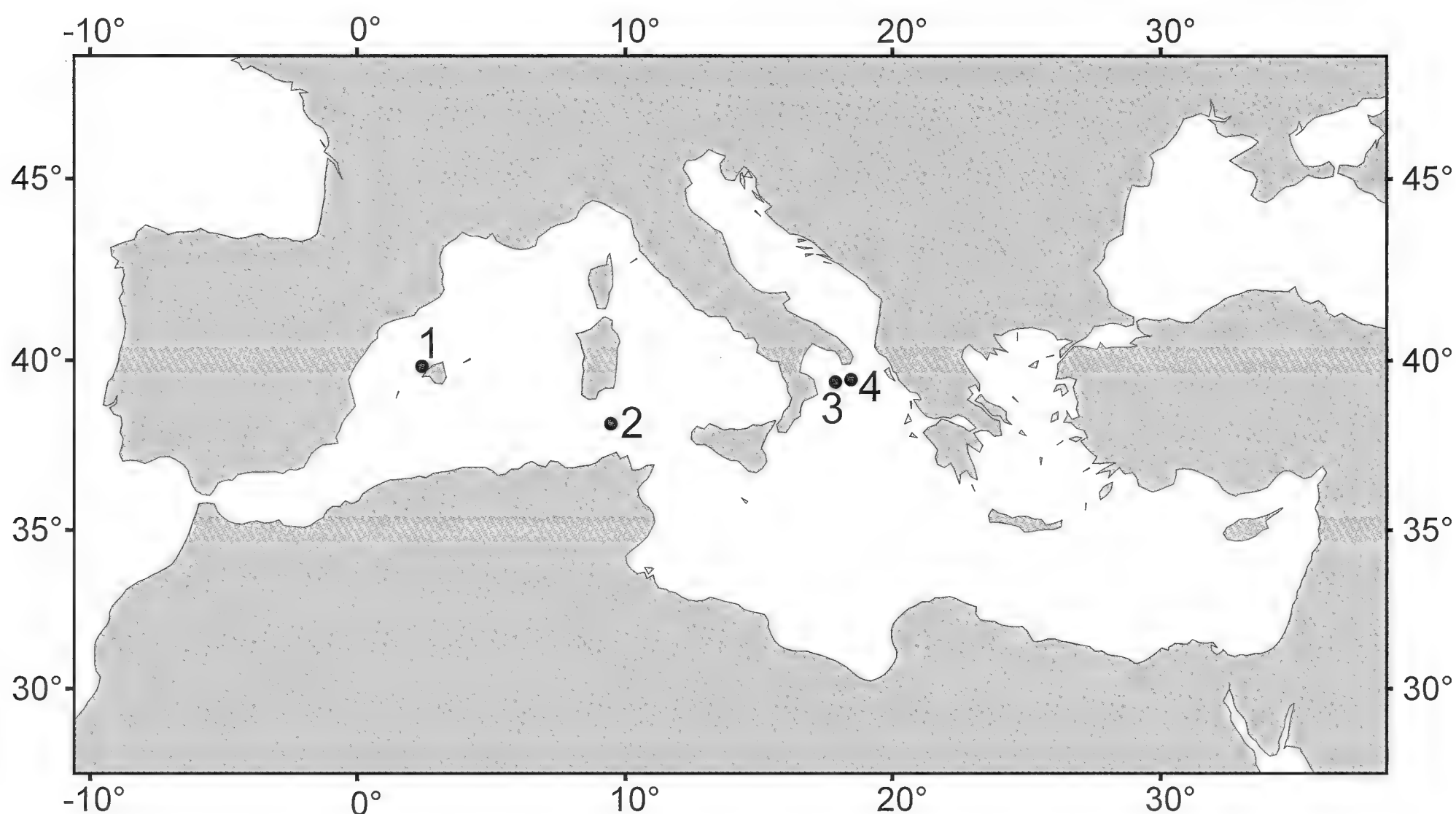
From the Mediterranean, Di Geronimo (1974) described *Halicardia ferruginea* from 2300-2400 m water depth on the Ionian abyssal plain (Mediterranean Sea). Examination of the type material, however, clearly demonstrates that his assignment of the species to the Verticordiidae is unjustified as the holotype shows a typical thyasirid hinge and there are no shell characters typical of the verticordiids such as a pearly internal shell layer, a distinctly developed granular sculpture on the outer shell surface and a more or less distinct cardinal tooth on the hinge plate below the beak. From the other shell characters like the posterior ridge, the crumpled wave-like sculpture and the shape of the shell it is evident that this species is identical with our recent findings and belongs to the genus *Axinus* within the Thyasiridae. By transferring *Halicardia ferruginea* Di Geronimo to the genus *Axinus* Sowerby, 1821 the species name would become a junior secondary homonym of *Axinus ferrugineus* Locard, 1886. But as clarified recently by Oliver & Killeen (2002), the name introduced by Locard (1886) is not valid.

Although no age determination of the type material of *Halicardia ferruginea* is at hand, it is likely from the locality data that it represents fossil material similar to the specimens described here. It should be remarked, however, that the type material was partially coated by a ferruginous deposit, not observed in our specimens. This coating is possibly a diagenetic feature of the hosting sediment or belongs to the living animal as observed in many living thyasirid species.

Di Geronimo also compared *Halicardia ferruginea* with *Verticordia axinoides* Seguenza, 1876. Examination of the specimen figured by Palazzi & Villari (1995) however showed that this species, despite great similarity in shell form and rugose sculpture, indeed belongs to the genus *Halicardia* Dall, 1895 in the family Verticordiidae as already supposed by Palazzi & Villari (1995).

The position of the ligament of *Axinus grandis* seems to depend on age: in smaller shells like those of "*Halicardia ferruginea*" and "*Mytilimeria fischeri*" the ligament is deeply sunken, apparently completely internal, whereas in fully grown and gerontic shells like the type specimens of *Axinus grandis* and "*Mytilimeria saharica*" the ligament protrudes beyond the outer shell face where a ligamental rim is developed along the posterior dorsal margin. We interpret these differences as related to growth stages rather than representing species diagnostic features. Moreover, all the other shell features such as sculpture, shell form, position and strength of dorso-ventral ridges agree so perfectly among all the specimens examined that there can be no doubt that all the material reviewed belongs to only one species, for which the oldest available name is *Cryptodon grandis*.





**Figure 6** Records of *Axinus grandis* (Verrill & Smith, 1885) from the Mediterranean Sea; 1: station COBAS-84; 2: eighty miles south-east of Cagliari in the Sardinia Channel (according to Bogi & Capua, 1995); 3: station R.A. 2 (see Di Geronimo, 1974); 4: station COR2-76

## DISTRIBUTION

*Cryptodon grandis* Verrill & Smith, 1885 is according to Payne & Allen (1991) the only known living representative of the genus *Axinus*. Apart from the records from the Mediterranean Sea (Fig. 6), the species is reported by Payne & Allen (1991) from isolated records in the North-West Atlantic (1715–2893 m), the Azores (1266 and 1385 m), the Bay of Biscay (1710 m), the Cape Verde Basin as well as the Rockall Trough, further off Cape Fear to Florida (155–1337 m) and the Yucatan Strait (1170 m), additionally by Locard (1898) from North off Spain (2651 m) and the Gulf of Gascogne (1143 m), West off the Sahara (1495 m) as well as West off Senegal (2924 m).

## HABITAT AND ECOLOGY

The family Thyasiridae is one of the major groups of infaunal bivalves (besides species of the Protobranchia and Septibranchia) inhabiting bathyal and abyssal depths, although representatives are also known from shallower depths (Payne & Allen, 1991). Thyasirids occur in highest diversity at the outer shelf and slope, but some are known to occur down to the greatest hadal depths (e.g., Knudsen, 1970; Payne & Allen, 1991; Fujikura et al., 1999). The deepest occurrences are recorded by Knudsen (1970: 222) based upon *Thyasira* sp. from 10,000 m in the Kermadec Trench and *Axinulus* sp. from 10,400–10,700 m in the Tonga Trench.

The species live infaunally in soft bottom, preferentially dark, soft clay respectively mud substrates. Most known recent thyasirids are associated with reducing, oxygen-poor, hydrogen sulphide-rich environments (e.g., Kauffman, 1967, 1969a, 1969b; Turner, 1985). In fact, their capability to host endosymbionts (see Dando & Southward, 1986;

Southward, 1986; Fujikura et al., 1999; Fujiwara et al., 2001; Dufour & Felbeck, 2003) renders such bivalves particularly adapted to colonize chemosynthetic environments as documented by modern (Clarke, 1989; Lewis & Marshall, 1996; Dando, 2001) and fossil occurrences (Goedert & Squires, 1990; Goedert et al., 1995; Zuschin et al., 2001). The genus *Thyasira* Leach in Lamarck, 1818 shows a cosmopolitan distribution in cold to warm temperate, marine waters.

Little is known about mode of life of the genus *Axinus*. Judging from the fossil record the representatives of *Axinus* lived in the same habitats as described above, but always in great water depth (slope to bathyal depths, comp. Löffler, 1999). They co-occur with species of *Thyasira* and/or other thyasirids (Gürs & Gürs, 1981; Báldi, 1986; Löffler, 1999). This also holds true for the samples investigated here in which *Thyasira granulosa* (Monterosato, 1874) is the most common bivalve, accompanied by another thyasirid, *Mendicula ferruginosa* (Forbes, 1844) as well as *Cardiomya costellata* (Deshayes, 1835), a further typical representative of such environments. Thus it can be assumed that *Axinus* lived in somewhat deep, fine-grained, possibly oxygen-poor environments. This is in accordance with the accompanying mollusc fauna of the COBAS-84 sample containing 45 mollusc species (Table 1).

## CONCLUSIONS

*Axinus grandis* (Verrill & Smith, 1885) is shown to be a representative of the latest Pliocene to earliest Pleistocene deep-sea fauna of the Mediterranean. Its occurrence in the Mediterranean basin was not recognised earlier because of the taxonomic misplacement of previous findings of this species. However, the question whether the species is still a member of the living fauna of the Mediterranean Sea at present must remain unanswered until living animals are discovered. Whether the record from the Ionian Sea described by Di Geronimo as *Halicardia ferruginea* belongs to the Recent fauna is uncertain (see above). In the Atlantic, *A. grandis* is known as a living species from isolated records in the Northern Atlantic from the Cape Verde Basin northwards to the Rockall Trough and the Bay of Biscay to the Yucatan Strait in the Caribbean.

*Mytilimeria fischeri*, *Mytilimeria saharica* and *Halicardia ferruginea* have to be considered synonyms of *Axinus grandis*. These findings demonstrate that, despite recently published detailed systematic literature on European and North Atlantic Thyasiridae (Payne & Allen, 1991; Oliver & Killeen, 2002) the inventory of described species is incomplete as sometimes thyasirids were described and grouped until today in other families even in different subclasses of the bivalvia.

*Axinus grandis* shows a strong allometrical ontogenetic development, juveniles having a completely internal ligament and a hinge line intermitted by a notch below the beak, while in adults part of the ligament becomes external, and a hinge plate develops which can get rather massive in gerontic specimens as the type of *Mytilimeria saharica*.

*Axinus* has a long geological record starting at least from the Early Eocene. Species included in this genus are *A. angulatus* Sowerby, 1821, *A. varus* (Korobkov, 1939) and *A. grandis* (Verrill & Smith, 1885). All these species are known only from deep-water sediments. They are associated with other thyasirids, indicating typical reducing, possibly oxygen-poor, hydrogen sulphide-rich environments.

TABLE 1  
Associated fauna of the COBAS-84 sample

CLASS	FAMILY	SPECIES
GASTROPODA	Lepetellidae	<i>Lepetella</i> cf. <i>labronica</i> (Bogi, 1984)
	Cocculinidae	<i>Cocculina mamilla</i> Di Geronimo, 1974
	Trochidae	<i>Jujubinus</i> sp. <i>Callumbonella suturalis</i> (Philippi, 1836)
	Rissoidae	<i>Alvania cimicoides</i> (Forbes, 1844)
		<i>Alvania testae</i> (Aradas & Maggiore, 1844)
		<i>Alvania subsoluta</i> (Aradas, 1847)
		<i>Benthonella tenella</i> (Jeffreys, 1869)
	Aporrhaidae	<i>Aporrhais</i> sp. (juvenil)
	Muricidae	<i>Trophonopsis echinatus</i> (Kiener, 1840)
	Columbellidae	<i>Amphissa acutecostata</i> (Philippi, 1844)
	Turridae	<i>Drilliola loprestiana</i> (Calcara, 1841)
		<i>Gymnobela abyssorum</i> (Locard, 1897)
		<i>Lusitanops lusitanica</i> (Sykes, 1906)
		<i>Eulimella scillae</i> (Scacchi, 1835)
	Pyramidellidae	<i>Turbonilla paucistriata</i> (Jeffreys, 1884)
	Cylichnidae	<i>Roxania utriculus</i> (Brocchi, 1814)
BIVALVIA	Nuculidae	<i>Ennucula aegeensis</i> (Forbes, 1844)
		<i>Ennucula bushae</i> (Dollfus, 1898)
	Yoldiidae	<i>Yoldiella messanensis</i> (Jeffreys, 1870)
		<i>Yoldiella philippiana</i> (Nyst, 1845)
	Arcidae	<i>Barbatia nodulosa</i> (Müller, 1776)
		<i>Bathyarca pectunculoides</i> (Scacchi, 1834)
		<i>Bentharca</i> sp.
	Mytilidae	<i>Modiolula phaseolina</i> (Philippi, 1844)
	Limidae	<i>Notolimea crassa</i> (Forbes, 1844)
	Pectinidae	<i>Chlamys bruei</i> (Payraudeau, 1826)
		<i>Chlamys pusio</i> (Linné, 1758)
		<i>Delectopecten vitreus</i> (Gmelin, 1791)
		<i>Similipecten similis</i> (Laskey, 1811)
		<i>Parvamussium fenestratum</i> (Forbes, 1844)
	Thyasiridae	<i>Axinus grandis</i> (Verrill & Smith, 1885)
		<i>Thyasira granulosa</i> (Monterosato, 1874)
		<i>Mendicula ferruginosa</i> (Forbes, 1844)
	Montacutidae	Montacutidae gen. et spec. indet. 1
		Montacutidae gen. et spec. indet. 2
	Cardiidae	<i>Parvicardium scabrum</i> (Philippi, 1844)
	Mesodesmatidae	<i>Ervilia castanea</i> (Montagu, 1803)
	Semelidae	<i>Abra longicallus</i> (Scacchi, 1834)
	Kelliellidae	<i>Kelliella abyssicola</i> (Forbes, 1844)
	Xylophagidae	<i>Xylophaga dorsalis</i> (Turton, 1819)
	Cuspidariidae	<i>Cardiomya costellata</i> (Deshayes, 1835)
	Verticordiidae	<i>Laevicordia gemma</i> (Verrill, 1880)
SCAPHOPODA	Dentaliidae	<i>Antalis agilis</i> (Sars, 1872)
	Entalinidae	<i>Entalina tetragona</i> (Brocchi, 1814)



## ACKNOWLEDGEMENTS

The authors thank Captains, Officers, Crew and Colleagues aboard RV *URANIA* for their skillful operations and assistance during the CORAL mission in August 2002 and the COBAS mission in April 2004. Furthermore we are very grateful to: Rudo von Cosel (Muséum national d'Histoire naturelle, Paris, France) who kindly made available the type material of *Mytilimeria fischeri* and *Mytilimeria saharica*, Italo Di Geronimo (Dipartimento di Scienze Geologiche, Università di Catania, Italy) for loan of the type material of *Halicardia ferruginea*, Jerry Harasewych and Paul Greenhall (National Museum of Natural History, Smithsonian Institution, Washington D.C., USA) for the loan of the type of *Axinus grandis*, Erlend Martini (Institute of Geology and Palaeontology, Frankfurt University, Germany) for the nannoplankton dating, Wolfgang Gerber (Institute for Geosciences, Tübingen University, Germany), Eike Neubert (Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany) and Marie-Luise Neufert (Institute of Palaeontology, Erlangen University, Germany) for the photography, Max Wisshak (Institute of Palaeontology, Erlangen University, Germany) for preparing the figures, Elena Krylova (Institute of Oceanology, Moscow, Russia) and Anders Warén (Swedish Museum of Natural History, Stockholm, Sweden) for helpful comments, as well as James H. Nebelsick (Institute for Geosciences, Tübingen University, Germany) and P. Graham Oliver (National Museum of Wales, Cardiff, U.K.) for their critical reading of the manuscript. CORAL mission ("Campagna Oceanografica Ricerca Ambiente *Lophelia*") was funded by CNR in the scope of the SINAPSI Project, Task D5, COBAS mission ("Deep-water Corals of the Baleares and Sardinia") within the ESF Euromargins MOUNDFORCE programme. This is IGM scientific contribution no. 1436.

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## STATUS OF *TRUNCATELLA SUBCYLINDRICA* (LINNAEUS, 1767) IN IRELAND

*Truncatella subcylindrica* (L., 1767), an upper shore/brackish-water rissoid gastropod was found in July 2000 living at Carrowmore, South Bay, Co. Galway, together with a second colony located at Rincarna, Co. Galway by one of us (SMS). This identification was confirmed by Dennis Seaward. These were the first live records for Ireland. There is one previous record for Ireland, which was, however, considered by Jeffreys (1867<sup>1</sup>) to be a mistake. This was of a young shell found at Bundoran, Co. Donegal amongst shell-sand by Mrs. Hancock (Thompson W. 1856<sup>2</sup>, Nichols A.R. 1900<sup>3</sup>).

Prior to the discovery in Ireland, the species had only been recorded living from the extreme south-west and south of England in Britain (see Light J.M. & Killeen I.J. 2000<sup>4</sup> for review). The colonies in Galway are currently the most northerly in the world. *Truncatella subcylindrica* (called the looping snail for its peculiar looping gait) is a British Red Data Book species, and has been described as Rare (Bratton J.H. 1991<sup>5</sup>). It is listed under the UK Biodiversity Action Plan. *T. subcylindrica* is small and easily overlooked. As it has a specialised habitat, the small number of colonies render it vulnerable.

A project was undertaken in 2001, supported by a grant from the Praeger Committee of the Royal Irish Academy, to study the ecology and associated fauna and flora of *Truncatella subcylindrica*, and to search for further colonies. A total of 50 site visits was made in August and November to Counties Clare, Galway, Kerry, Mayo and Wexford, with more detailed work undertaken at the two known colonies at Rincarna and Carrowmore. For each site, a basic description, species list, photographs and sketch map were taken. Water samples were taken at most sites, stored, and returned to Northern Ireland where salinity was measured by a conductivity meter supplied courtesy of C-Mar, Queen's University Belfast. Where a GPS was available, eight-figure grid references were noted for samples. More detailed notes were made for the two sites Carrowmore and Rincarna where living *Truncatella subcylindrica* was found.

In many invertebrates there is a tendency for habitat preferences to become narrower close to the northern range limits. At Rincarna and Carrowmore, *Truncatella subcylindrica* was confined to muddy gravel near the top of the shore, on shingle spits impounding brackish lagoons, often in gravel under large boulders. The gravelly habitat is probably inundated only at spring tides but is kept constantly moist by the impoundment of the lagoon, which leaches through the spit back into the sea. It has been observed on or in *Vaucheria* inside an inundated lagoon, and can stand immersion in fully saline water for some days, although it is primarily amphibian or terrestrial. From observations, it is clear that *T. subcylindrica* requires constant moisture, high (near fully marine) salinity, and gravelly or bare rock surfaces, which serve to absorb the sun's heat.

### CARROWMORE LAGOON

*T. subcylindrica* was cryptic and difficult to find. Only three specimens in total were found under two large boulders deeply embedded in the seepage between the two ends of the gravel ridges. Salinity was 30.8-31.1‰. Nine specimens were found some distance away under a very deeply embedded large boulder resting in a grass hollow. The hollow was damp, but there was no standing water at the time of the discovery of *Truncatella subcylindrica*. On a later visit, after a spring tide incursion, the hollow was filled to a depth of 1m, by salt water. All specimens at this, and at the second colony were un-ribbed.

The relatively large number found in this habitat suggests they are largely hypogeal, but probably not uncommon near the water-table within the soil. The localisation of *T.*

*subcylindrica* at the site probably reflects only the incidence of boulders large enough to impinge upon its subterranean habitat. It evidently avoids the undersides of small stones and/or is restricted to depths greater than 5cm in the gravelly till it prefers.

*Ovatella myosotis* (Draparnaud, 1801) and *Auriculinella bidentata* (Montagu, 1808) were common in the same habitat at the seepage and boulders, and more widely outside the 'Truncatella area'. *Hydrobia ulvae* (Pennant, 1777) and a dead shell of *Lasaea rubra* Montagu, 1803 were also found.

#### RINCARNA LAGOONS

Nine *Truncatella subcylindrica* were detected under boulders among vegetation inside the shingle bar at the eastern end of the East Lagoon, but this area generally did not appear to provide favourable living conditions. Seventeen *T. subcylindrica* were found under several deeply embedded boulders in the seepage area (between the open sea and the lagoon) between the ends of the gravel ridges. Salinity was 29.4-30.4‰. Of the gastropods, only *Littorina saxatilis* (Olivi, 1792) and *Hydrobia ulvae* were detected.

A portion of algal sheet (*Vaucheria* sp.) approximately 100cm<sup>2</sup> in area was retained in the laboratory from the West Lagoon (linked to East Lagoon by a seepage channel). After several days, two adult and three juvenile *Truncatella subcylindrica* emerged. This could extrapolate to a density of 500 per sq. metre! Mollusca were scarce but the marine prosobranchs *Onoba semicostata* (Montagu, 1803) and *Skeneopsis planorbis* (O Fabricius, 1780) were present on the *Vaucheria* with small numbers of *Hydrobia ventrosa* (Montagu, 1803) and *H. ulvae* and the opisthobranch *Limapontia depressa* Alder & Hancock, 1862. *Littorina saxatilis* and *Ovatella myosotis* were present sparingly on the lagoonal margins.

Three shells of *Truncatella subcylindrica* were also found in shell sand from Rine Point, Co. Clare. A search at 47 other sites in the counties listed above failed to find new colonies with live shells. From this, it is clear that the following characteristics are indicative that a site is very unlikely to contain a colony of *T. subcylindrica*:

- the shingle bank is too well drained (i.e. too dry), and not in close contact with the water table or the lagoon behind it.
- there is too much freshwater running into the lagoon from the landward side reducing salinity significantly below fully marine. *T. subcylindrica* was found in salinities ranging from 27.8‰ to 31.1‰.
- the shingle bank is not sufficiently scoured by the tide. As a result, a more substantial saltmarsh or halophyte community develops. This type of community traps silt, creating an organic sediment with poorer drainage than the gravelly sediments which *T. subcylindrica* inhabits.
- heavy vegetation is present which reflects sunlight and prevents heating of the substratum, which a thermophilic species requires.

The Rincarna and Carrowmore sites are possibly unique in Ireland, although there is a slight chance that similar sites may exist in Co Kerry. Bishopsquarter, close to Rine Point where the three shells of *T. subcylindrica* were found, had some similar habitat characteristics to both Rincarna and Carrowmore lagoons. The salinity however at this site was considerably lower than at those two colonies. It is possible that human interference (construction of bridge and car park) destroyed any extant colony, and restricted incursion of fully marine water. Lough Murree, Co. Clare also has some of the appropriate habitat characteristics, but has largely been cut off from saline incursion by the construction of a tarmac road. Salinity in the lake is possibly still augmented by seepage underneath the roadway, but there is strong evidence that the saline content of the lake's waters has been decreasing over the last decade. Any colonies of *T. subcylindrica* may also have been destroyed during construction.



Both lagoons with known colonies are small, and very vulnerable to disturbance. There has already been some dumping of rubbish at the western end of Rincarna lagoons. A further visit to Carrowmore by one of us (JDN) in April 2003 discovered that an un-cemented stone and gravel farmers track had been constructed over the seepage area, almost certainly destroying the tidal regime. No specimens of *Truncatella subcylindrica* could be found. It is suggested that these two sites be considered for maximum protection under available conservation legislation in Ireland.

The authors thank Dennis Seaward for confirming the identity of *Truncatella subcylindrica*, Brenda Healy for useful discussions, and the Praeger Committee for the grant to enable this work to take place.

#### Note

Latitudes and longitudes for the sites for *Truncatella subcylindrica* are not published here, but may be supplied upon application to one of us (JDN). Full descriptions for all the sites visited are available from the report supplied to the Royal Irish Academy, Dublin.

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## ANOTHER FRENCH SITE FOR LIVING *PSEUDOTRICHIA RUBIGINOSA*

With reference to the article of Cucherat & Demuynck in this journal <sup>1</sup>, who mention the first find of *Pseudotrachia rubiginosa*, I would like to report here another population of this species in France.

During a malacological survey of the River Aisne (a tributary of the River Oise which flows into the River Seine) this snail was found between Cuiry-les-Chaudardes and Beaurieux, ca. 30 km east of Soissons (Northern France). The site is situated 1700 m WSW of Cuiry-les-Chaudardes, along the northern edge of the river valley. At the foot of a slope of some metres high we found an isolated oblong pool of several hundreds of square metres, probably the remnant of a former oxbow lake.

The valley of the river is here for a large part used as meadow, for a smaller part as arable land. Scattered trees are present, the edge of the river valley and the bank of the river itself are overgrown with a narrow zone of trees and shrubs. Only periodically,

during very high waterlevels, does the water flow over the grasslands and reach the site. On these occasions the river deposits at many places a layer of plant remains along the highwater line.

On 26 August 1998 *P. rubiginosa* was found along the edge of the pool. The specimens were creeping on the bare, moist soil, between a sparse vegetation and some dead plant material. During a second visit on 12 August 1999, only one empty shell was found. It was not possible to find the species during visits on 22 August 2000 and 4 August 2002, although the situation had not noticeably changed. I expect that the population is small at this place. Other species found together with *Pseudotracha rubiginosa* are, common – *Zonitoides nitidus*, *Trichia hispida*, *Oxyloma* sp. and *Galba truncatula* and, rare – *Vallonia pulchella*, *Vitrea crystallina* and *Cochlicopa lubrica*. In the pool itself live *Acroloxus lacustris*, *Anisus vortex*, *Anisus leucostoma*, *Bithynia tentaculata*, *Gyraulus albus*, *Hippeutis complanatus*, *Lymnaea stagnalis*, *Musculium lacustre*, *Planorbarius corneus*, *Radix ovata* and *Valvata piscinalis*.

Conditions as described here are present at more sites in the valley of the River Aisne. I expect that *P. rubiginosa* can be found at more places along this river. The environment is not under the influence of the freshwater tides.

<sup>1</sup> Cucherat X. & Demuyne S. 2004. *J. Conch.* 38: 317-321.

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## SPURWINKIA SALSA (PILSBRY 1905) (GASTROPODA: HYDROBIID) IN THE KENNEBECASIS ESTUARY, NEW BRUNSWICK: A BRACKISH-WATER SNAIL NEW TO CANADA.

The brackish-water gastropod *Spurwinkia salsa* is reported in Canada for the first time, from the Kennebecasis estuary, New Brunswick. This extends the known distribution about 280 km northward from the Weskeag River salt marsh, Maine.

Davis *et al.* (1982) erected the genus *Spurwinkia*, and expanded the definition of the Hydrobiidae, to accommodate a morphologically unique hydrobid described by Pilsbry<sup>1</sup> as *Paludestrina salsa*, from brackish-waters in Massachusetts. To date, *Spurwinkia salsa* has been recorded from only about 11 estuarine sites northward from the Delmarva Peninsula, Maryland, to the Weskeog River, Maine<sup>2, 3</sup>. Here we document the presence of this snail in Canada for the first time, extending the species range northward by about 280 km. We also describe features of habitat for this little-known brackish-water mollusc.

During the course of field studies in June-September 2004 in the Kennebecasis estuary, New Brunswick (45° 23' N 66° 02' W), *S. salsa* was found to be common and widespread from the estuary mouth to the head. The Kennebecasis estuary has a surface area of 44 sq km, a tidal range of about 0.6 m, and a mean depth of approximately 30-33 m<sup>4</sup>. The estuary empties into the Saint John River and has a brackish surface layer 5-15 m thick overlying a deep saline layer. The salinity of the deep layer remains relatively constant at 21-23 ppt while the surface layer is reported to vary from 0-10 ppt<sup>4</sup>. An average annual freshwater discharge of about 935,000 cu l/sec from the Saint John

where it joins the mouth of the Kennebecasis, combined with a distinctive rock sill at the estuary mouth, controls the thickness of the brackish layer<sup>4</sup>. With the exception of several shallow mud-bottom coves, the shoreline to about 2 m depth is typically coarse gravel or rock, at which point the substrate grades rapidly to a mud or a silt-gravel mix. Water-logged wood and woody detritus, some of it remnants of wharves and the refuse of now ceased logging or milling activities, litter the bottom in certain areas. Our sampling, carried out using glass-bottomed boxes and via snorkeling and SCUBA, was restricted to waters up to 6 m in depth.

*Spurwinkia salsa* has been characterized as a euryhaline snail endemic to the upper reaches of estuaries<sup>3</sup>. Habitats in which the species has been recorded previously include tidal creeks and pools associated with *Typha-Scirpus* and *Spartina* marshes, intertidal marsh turf below mean highwater, and shallow subtidal waters of channels and embayments bordered by tidal marshes<sup>3</sup>. Davis *et al.*<sup>3</sup> note that the salinities in habitats in which the species occurs range from 0-30 ppt, although Mazurkiewicz<sup>5</sup> reports the lower limit of salinity tolerance for adult *S. salsa* as 0.1 ppt. In suitable habitat *S. salsa* may be the only hydrobiid present or may occur in association with *Hydrobia truncata* or *Amnicola winkleyi*<sup>3</sup>.

Our identification of *S. salsa* is based on dissection of menthol-narcotized snails and subsequent examination of the penis. Both dry shells and ethanol-preserved vouchers from each of 22 sites in the Kennebecasis estuary where we recorded this snail have been deposited in the collections of the New Brunswick Museum. In the Kennebecasis estuary *S. salsa* was collected at water depths of < 0.25 m to 6 m and at salinities of 3.9-14.4 ppt. The species undoubtedly also occurs in deeper, more saline, portions of the Kennebecasis that we did not sample. *Spurwinkia salsa* was clearly associated with mud or silt bottoms in the Kennebecasis, an association also apparent in the data reported for the Sheepscot estuary, Maine<sup>6</sup>. Normally, we collected snails by SCUBA diving in water of 2 m or greater, the point at which the gravel shallows had graded to mud and generally beyond the point at which aquatic macrophytes occurred. In this habitat the species was most readily collected by hand from water-logged wood and woody detritus or silt covered rocks. This is in contrast to the Sheepscot estuary where *Spurwinkia* is noticeably absent from a list of molluscs collected from subtidal sediments and where the species is apparently confined to the intertidal<sup>6</sup>. However, we found *S. salsa* most abundant on the Kennebecasis in <0.25-1.5 m of water at two sites where mud-bottomed substrates reach the shoreline, McCormack Cove and Matthew Cove. The former is in the lower estuary, the latter in the upper. Aquatic macrophyte communities at both of these sites were dominated by *Potamogeton perfoliatus*. There was also a very heavy growth of filamentous algae at Matthew Cove. The Kennebecasis estuary is somewhat uncharacteristic of previously reported habitat for *S. salsa*. There are no salt marshes in the estuary and the shoreline is typically dominated by mixed forest or suburban development. To date no other species of hydrobiid has been recorded in the estuary.

Acknowledgements: Information reported here was collected during a project to investigate mollusc communities in the Kennebecasis estuary. Financial support was provided in the form of grants to DFM through the Community-University Research Alliance program of the Social Sciences and Humanities Research Council of Canada, the Salamander Foundation, and the New Brunswick Wildlife Trust Fund. We are grateful to Jo-Anne Steves, UNBSJ Biology Department, for the loan of a dissolved oxygen meter, and to the following for their assistance in the field; Andrew Albert, Gart Bishop, Rachel Maillet, Fenning McAlpine, Lynne McAlpine, and Erin Smith.

<sup>1</sup> Pilsbry, H.A. 1905. Nautilus 19: 90-91.

<sup>2</sup> Gore, J.F. 1967. Nautilus 80: 112-113.

<sup>3</sup> Davis, G.M., M. Mazurkiewicz, and M. Mandracchia. 1982. Proc. Acad. Nat. Sc. Philadelphia



134: 143-177.

<sup>4</sup> Trites, R.W. 1960. J. Fish. Res. Bd. Can. 17: 377-408

<sup>5</sup> Mazurkiewicz, M. 1972. Amer. Zool. 12: 726.

<sup>6</sup> Stickney, A.P. 1959. U.S. Dept. Inter. Spec. Sci. Rpt. – Fish. No. 309. Wash. D.C.

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## HYGROMIA CINCTELLA IN IRELAND

*Hygromia cinctella* (Draparnaud) is a common Mediterranean land snail, found on waste ground on well-drained, base-rich soils. It was first noted in Britain in 1950 at Paignton in Devon, where it had possibly been introduced with nursery or garden plants (Comfort <sup>1-2</sup>). For many years its British range was restricted to this small area of South Devon where it became firmly established. In the last 25 years it has spread rapidly out of its South Devon stronghold into a number of neighbouring counties in the south-west, extending eastwards as far as Kent (Kerney 1999<sup>3</sup>).

On 19 August 2004, several immature specimens of *H. cinctella* were found amongst damp leaf litter in the margin of the wood opposite the entrance of the hotel Ard na Sidhe (V742913), on the eastern side of Lough Caragh, County Kerry. The woodland contained many sycamore trees and formed quite a dense canopy, so the site was not typical for this species. It was associated with *Trichia striolata*, *Cepaea nemoralis*, *Aegopinella nitidula*, *Oxychilus cellarius*, *O. alliarius* and *Semilimax pyrenaicus* (a new vice-county record for this local Irish species). This is the first time that *H. cinctella* has been recorded from Ireland, although it was found on pot plants in a garden in Lisburn, County Antrim in 1999 (R. Anderson, personal communication). It is clearly rare in Ireland at the present time but this situation is likely to change in the coming years. This species seems to be particularly prone to dispersal by horticultural activity, although why it took several decades to begin its spectacular exit from Devon is not entirely clear, unless this can be linked with the increasing popularity of gardening.

<sup>1</sup> COMFORT A. 1950 *J. Conch., Lond.* **23**: 99-100.

<sup>2</sup> COMFORT A. 1951 *J. Conch., Lond.* **23**: 136.

<sup>3</sup> COMFORT M.P. 1999 *Atlas of the land and freshwater molluscs of Britain and Ireland*. Harley Books, Colchester.

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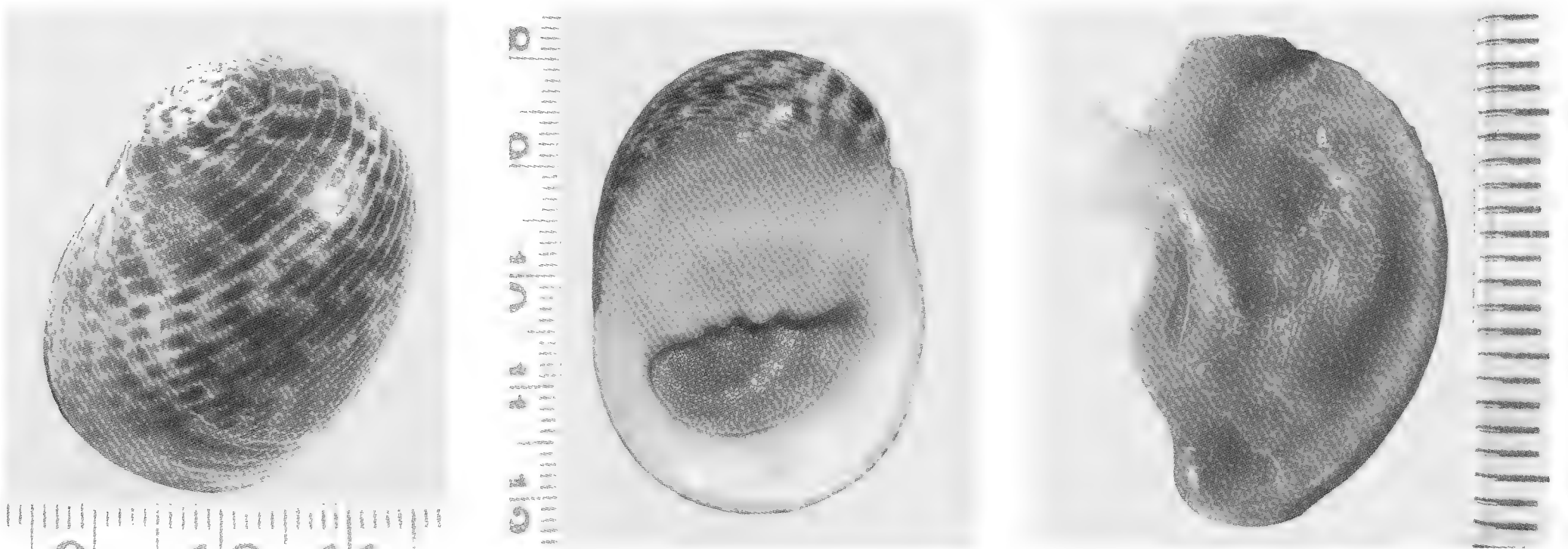
## A NEW RECORD OF *NERITA* (*RITENA*) *MAXIMA* GMELIN, 1791 (MOLLUSCA: GASTROPODA: NERITIDAE) FROM THE WEST COAST OF INDIA (ARABIAN SEA)

Genus *Nerita* (Gastropoda) representing the Order Archaeogastropoda and Family Neritidae includes 15 species from the Indian sub-continent<sup>1</sup>. Most of these species are recorded from rocky intertidal substrata although some of them (e.g. *Nerita planospira*, *N. squamulata*, *N. grayana* and *N. articulata*) are known to occur from swamps and mangrove areas. Typical marine *Nerita* are vegetarians and live under rocks or in crevices, usually at high tide level in the intertidal region. Important works on Genus *Nerita* include those from Gulf of Mannar<sup>2</sup>, Coramandel coast<sup>3</sup>, LakshawEEP<sup>4</sup>, Mahanadi estuary<sup>5</sup>, Orissa<sup>6</sup>, West Bengal<sup>7</sup> and several other locations in the Indian subcontinent<sup>1,8-14</sup>. As a part of the ongoing research on the taxonomy of marine gastropods from the east and west coasts of India, the authors came across a single (live) individual of *Nerita* (*Ritena*) *maxima* from a rocky outcrop at St. Mary's Island along Udupi coast (13°20'55"N; 74°43'00"E) near Mangalore on the west coast of India. *N. maxima* has not been reported earlier from the mainland. The present record of the species from the west coast is considered significant since *N. maxima* is a rare form on account of its very limited distribution. Earlier, Satyamurty (1952) reported *N. maura* Recluz from Gulf of Mannar, which could be *N. maxima* (pers. comm. N.V. Subba Rao). The present finding of *N. maxima* is a confirmation of the species' distribution on the mainland in the sub-continent after its original encounter from Andaman and Nicobar Islands.

Shell large, obliquely oval, thick, solid, spire consists of 2½ whorls, narrow, body whorl large and somewhat compressed in the middle, spire scarcely exerted, concavely flattened, nuclear whorls smooth and gleaming white. Aperture broadly expanded, columellar callus smooth in the upper part but obscurely wrinkled in the lower part, columellar margin concave, with four stout teeth in the middle, outer lip thickened and expanded, there are 36 fine teeth of uniform size on the inner side, and on the either side smooth. Outer surface sculptured with numerous flat spiral ribs separated by narrower grooves.

Colour: Grayish-black, sparingly interrupted with ash white, callus porcellaneous white, aperture white, outer lip flecked. Operculum pale gray with numerous granules on its outer surface, internal surface smooth, light flesh red colour with two gray broader bands parallel to the outer margin, apophyses well developed, pale orange in colour, anterior end flat and pale yellow.

Measurements: Total Length: 40mm; Width 29 mm. Aperture: length- 32mm; width 16 mm. Operculum: length 18 mm; width 6 mm.



Distribution: India: Andaman & Nicobar Islands, Gulf of Mannar (Pamban, Shingles Island), Elsewhere: Indo-Pacific.

Remarks: *Nerita maxima* is common in Andaman & Nicobar Islands, but not found from the mainland<sup>1</sup>. The species' distribution now extends to the mainland as well.

- <sup>1</sup> Subba Rao, N.V., Rec. zool. Surv. India, 2003, Occ. Pap. No. 192, 1-416, 96 pls., 40figs.
- <sup>2</sup> Satyamurti, S.T., Bull. Madras Govt. Mus. new Ser., 1952, 1(2), pt. 6, 1-265, 34 pls.
- <sup>3</sup> Rajagopal, A.S. and Mookherjee, H.P., Rec. zool. Surv. India, 1978, Occ. Pap. No. 12, 48 pp., 1 pl.
- <sup>4</sup> Surya Rao, K.V. and Subba Rao, N.V., Zool. Surv. India State Fauna Series, 1991, 2, 273-362, 3 pls.
- <sup>5</sup> Surya Rao, K.V. and Maitra, S., Zool. Surv. India: Estuarine Ecosystem Series, 1998, 3, 161-197.
- <sup>6</sup> Subba Rao, N.V., Surya Rao, K.V., Maitra, S., 1991, Zool. Sur. India: State Fauna Series, 1, 1-175, xxx pls.
- <sup>7</sup> Subba Rao, N.V., Dey, A., Barua, S., Zool. Sur. India: State Fauna Series, 1992, 3, 129-268, 30 pls.
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- <sup>9</sup> Govindan, K. and Natarajan, R., Proc. Indian Natn. Sci. Acad., 1972, 38B (3&4): 225-239.
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- <sup>13</sup> Apte, D. 1998. in The Book of Indian Shells. Bombay Natural History Society, Oxford University Press, Mumbai, 1-115, XIII pls.
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Acknowledgements: We are grateful to the Ministry of Environment and Forests, Government of India for financial support. Facilities at the Marine Biological Laboratory, Andhra University were utilised. One of us (TG) is thankful to the Department of Ocean Development, Government of India for financial support.

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# Journal of Conchology

Vol. 38, Part 5, May 2005



## Contents

### PAPERS

	PAGE
TAYLOR. J.D., GLOVER E.A., ZUSCHIN M., DWORSCHAK P.C. & WAITZBAUER W. Another bivalve with dreadlocks: living <i>Rasta lamyi</i> from Aqaba, Red Sea (Bivalvia: Lucinidae).	489
ROLAN E. & HERNANDEZ J.M. The west African species of the group <i>Nassarius denticulatus</i> (Mollusca, Neogastropoda), with the description of a new species.	499
FISCHER M.A. & CERVERA J.L. <i>Baptodoris peruviana</i> (D'Orbigny, 1837) Comb. Nov. an alternative taxonomic placement for <i>Doris peruviana</i> (Gastropoda: Nudibranchia: Doridoidea).	513
CAMERON R.A.D. & POKRYSZKO B.M. Estimating the species richness and composition of land mollusc communities: problems, consequences and practical advice.	529
HOLYOAK G.A., TURK S.M. & CAMERON R.A.D. Land molluscs on the Isles of Scilly: species richness and composition related to area.	549
BELLO G. <i>Abraliopsis morisii</i> vs <i>Abraliopsis pfeifferi</i> (Cephalopoda: Enoploteuthidae): Which is the right name?	561
MANGANELLI G. & GIUSTI F. The status and relationships of <i>Vitrina polloneriana</i> Fra' Piero, 1897, with description of <i>Sardovitrina</i> n. gen. (Gastropoda: Pulmonata: Vitrinidae).	567
LOEFFLER S.-B., JANSSEN R., GURS K.R. & TAVIANI M. The genus <i>Axinus</i> Sowerby, 1821 in the Mediterranean Basin (Bivalvia: Thyasiridae)	581

### COMMUNICATIONS

NUNN J.D., SMITH S.M. & ANDERSON R. Status of <i>Truncatella subcylindrica</i> (Linnaeus, 1767) in Ireland.	599
KUIJPER W.J. Another French site for living <i>Pseudotrachia rubiginosa</i> .	601
MCALPINE D.F., BATEMAN D. & DAVIS C.A. <i>Spurwinkia salsa</i> (Pilsbry 1905) (Gastropoda: Hydrobiid) in the Kennebecasis estuary, New Brunswick: A brackish-water snail new to Canada.	602
PREECE R.C. <i>Hygromia cinctella</i> in Ireland.	604
GANESH T., PADHY S.K., RAO Y.K.V., RAO K.V.S. & RAMAN A.V. A new record of <i>Nerita</i> ( <i>Ritena</i> ) <i>maxima</i> Gmelin, 1791 (Mollusca: Gastropoda: Neritidae) from the West Coast of India (Arabian Sea).	605

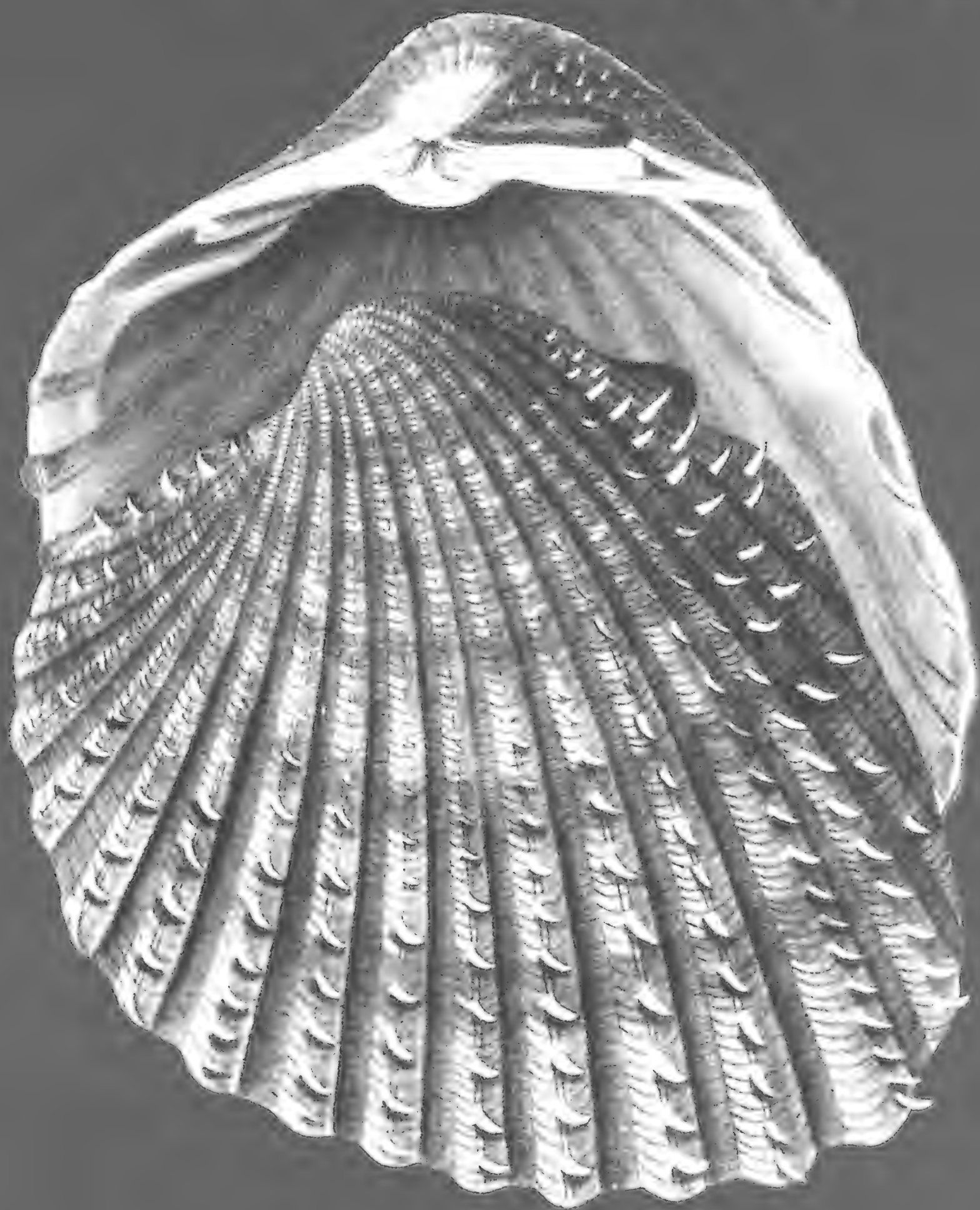
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# Journal of Conchology

(Established 1874)

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Pages put together by Anna M. Holmes, National Museum of Wales,  
Cathays Park, Cardiff CF10 3NP

Printed by Henry Ling, The Dorset Press, Dorchester DT1 1HD



# AN ANNOTATED LIST OF THE NON-MARINE MOLLUSCA OF BRITAIN AND IRELAND

ROY ANDERSON<sup>1</sup>

*Abstract* An updated nomenclatural list of the non-marine Mollusca of the Britain and Ireland is provided. This updates all previous lists and revises nomenclature and classification in the context of recent changes and of new European lists, including the Clecom List. Cases are made for the usage of names in the List by means of annotations. The List will provide a basis for the future census and cataloguing of the fauna of Britain and Ireland.

*Key words* Taxonomic, list, nomenclature, non-marine, Mollusca, Britain, Ireland, annotated.

## INTRODUCTION

There has been a need for some time to modernise the list of non-marine Mollusca for Britain and Ireland, a subject last visited in this journal in 1976 (Waldén 1976; Kerney 1976). Many of the changes that have appeared in the literature since then are contentious and Kerney (1999) chose not to incorporate many of these into the latest atlas of non-marine Mollusca of Britain and Ireland. A new European List, the Clecom List (Falkner *et al.* 2001) has now appeared and it seems appropriate to examine in more detail constituent changes which might affect the British and Irish faunas. This is given additional urgency by the inception of a new census of the molluscs of Britain and Ireland by the Conchological Society. Recorders in the Society are aware of many of the proposed changes but unable to implement them without general agreement. In addition, many field malacologists make use of the recording package RECORDER, a recent form of which has been developed jointly by JNCC and the National Biodiversity Network in the United Kingdom. The species lists for invertebrates in RECORDER 2002 and future editions of the software are not yet finalised but the contract for their assemblage is with staff in the Natural History Museum (NHM). An up-to-date mollusc list would inform mollusc recording through RECORDER and also through the National Biodiversity Network and assist the implementation of Biodiversity Action Plans within the UK. Recent developments, such as the publication of an Irish List derived directly from Clecom (Moorkens & Speight 2001) and the publication of an Aidgap Guide to molluscs (Cameron 2003), which differ significantly on many points, add further urgency to the need for a new list upon which all can agree.

Colleagues in the Natural History Museum have been consulted with the object of achieving a common position on as many of the more controversial proposed changes, as possible. The revised list for Great Britain and Ireland given below, has been developed from discussions not only with NHM staff but with others in the Conchological Society, and is an attempt to set a generally accepted standard for recorders and researchers. All lists inevitably date and this list is no exception. Necessary information on some of the problem groups is currently lacking, and is likely to come about only through detailed phylogenetic studies. As results from such studies become available more changes will be sought and justified. As far as is possible, where there is ambiguity or a lack of information to decide upon a particular name or status for an organism, the issues are stated in annotations after the List. Changes to the lists of Kerney (1976) and Waldén (1976) are indicated in synonymy so that the reader can follow the evolution in usage

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and be able to place names, which these authors used, in a current context.

The List updates all previous lists (Kerney 1976; Waldén 1976; Kerney 1999; Moorkens & Speight 2001, Cameron 2003) and enumerates those molluscan species known to have established persistent or permanent breeding populations in Great Britain and Ireland. The List includes a supplementary list of hothouse aliens, but not fossil species, nor temporary introductions. Hothouse aliens are included because of the number of species which have made the transition from artificially heated environments to outdoor environments in the past. This process of acclimatisation and naturalisation of alien fauna seems likely to continue in an era of climate warming. It has also led to some serious misunderstandings of the complement of native fauna in Europe, due to early or otherwise cryptic introductions, particularly from North America. The List includes peri-marine fauna as well as non-marine fauna. There has been little consensus in previous lists for Great Britain and Ireland on which species qualify as non-marine. The position taken here is a wide one and follows the Clecom List to include both estuarine species and upper shore species, but essentially those judged to be capable of breathing air or of surviving immersion in freshwater for substantial periods.

European taxonomists are split upon many proposed, particularly recent, changes in taxonomy and the phylogeny of the fauna. The List given here in the main follows the Clecom system but differs on points of detail relating partly to the validity of species to be included in a British and Irish List but mainly on the wider validity of recognised taxonomic units. In general a precautionary principle has been applied to changes which are not well established, differ from long-established precedent, or are not supported by appropriate phylogenetic analysis. Where opinion differs significantly from the Clecom List or practice elsewhere, this is elaborated in the Notes section. Among the many factors complicating interpretation of biological species is the very variable degree to which self-fertilisation occurs in different species and species-groups. This has been largely missed by traditional conchological ordination but it is becoming increasingly clear, from the many recent phylogenetic studies published, that self-fertilisation is relatively common. This leads to partial breeding isolation within sympatric populations making it difficult to interpret biological species on morphology alone. Wherever possible the present List draws upon phylogenetic evidence to justify names and placings of species. Another major difficulty has been with the higher classification adopted in Clecom, which differs significantly from previous systems and has been commented upon in a critical fashion by reviewers (Davis 2004). The present List is aimed primarily at the recording community in Britain and Ireland so the details of higher classification are largely irrelevant. The List is therefore presented, within orders, families and genera in alphabetical, rather than systematic, order. This avoids most of the problems relating to higher systematics at a time when molecular studies are changing fundamentally the thinking about these things.

The List comprises 213 native and naturalised taxa, and 14 hothouse aliens. Of the non-hothouse species 209 species have been recorded in Britain, though two are now considered extinct, and 163 in Ireland. The inclusion of each species is indicated by GB (Britain) and IRE (Ireland) to the right of the species names in the List. Species established in historical times but now considered extinct are included with an 'E' in brackets beside the relevant geographical designation. Subfossil occurrences are disregarded. So, largely, are subspecies. The use of the subspecies designation has been so widely confused, and in turn abused, in taxonomic literature that it should only be accepted with extreme reserve (Davis 2004). The term is here taken to indicate allopatric populations with incipient potential, because of geographical isolation, for producing a new species. Only two examples are included in the List, one, *Hydrobia acuta* s. *neglecta*, being justified on recent phylogenetic evidence (Wilke *et al.*, 2000).

**CLASS GASTROPODA CUVIER, 1795 \*****ORDER NERITOPSINA COX & KNIGHT, 1960****FAMILY NERITIDAE Lamarck, 1809****Genus *Theodoxus* Montfort, 1810***Theodoxus fluviatilis* (Linnaeus, 1758)

GB IRE

**ORDER ARCHITAENIOGLOSSA HALLER, 1890****FAMILY ACICULIDAE Gray, 1850****Genus *Acicula* Hartmann, 1821***Acicula fusca* (Montagu, 1803)

GB IRE

**FAMILY VIVIPARIDAE J. E. Gray, 1847****Genus *Viviparus* Montfort, 1810***Viviparus contectus* (Millet, 1813)

GB

*Viviparus viviparus* (Linnaeus, 1758)

GB IRE

**ORDER NEOTAENIOGLOSSA HALLER, 1892****FAMILY ASSIMINEIDAE H. & A. Adams, 1856****Genus *Assiminea* Fleming, 1828***Assiminea grayana* Fleming, 1828

GB IRE

**FAMILY BITHYNIIDAE Troschel, 1857****Genus *Bithynia* Leach, 1818****Subgenus *Bithynia* Leach, 1818***Bithynia tentaculata* (Linnaeus, 1758)

GB IRE

**Subgenus *Codiella* Locard, 1894***Bithynia leachii* (Sheppard, 1823)

GB IRE

**FAMILY HYDROBIIDAE Troschel, 1857****Genus *Heleobia* Stimpson, 1865***Heleobia stagnorum* (Gmelin, 1791)

GB(?E)

**Genus *Hydrobia* Hartmann, 1821***Hydrobia acuta* (Draparnaud, 1805)s. *neglecta* (Muus, 1963) <sup>1</sup>

GB IRE

*ventrosa* auct. partim non Montagu, 1803**Genus *Marstoniopsis* van Regteren Altena, 1936***Marstoniopsis insubrica* (Küster, 1853) <sup>2</sup>

GB

*schoeltzi* (A. Schmidt, 1856)

\* In the List, valid names of species are in italic type, subspecies names follow the names of the parent species preceded by an 's.', and synonyms are listed in an indent below the species name but in reduced italic type rather than in italic type.



Genus *Mercuria* Boeters, 1971  
*Pseudamnicola* Paulucci, 1878, partim  
*Mercuria* cf. *similis* (Draparnaud, 1805) <sup>3</sup> GB IRE  
*confusa* auct. non (Frauenfeld, 1863)

Genus *Peringia* Paladilhe, 1874  
*Hydrobia* Hartmann, 1821 partim  
*Peringia ulvae* (Pennant, 1777) <sup>4</sup> GB IRE

Genus *Potamopyrgus* Stimpson, 1865  
*Potamopyrgus antipodarum* (Gray, 1843) GB IRE  
*jenkinsi* (E. A. Smith, 1889)

Genus *Ventrosia* Radoman, 1977  
*Hydrobia* Hartmann, 1821 partim  
*Ventrosia ventrosa* (Montagu, 1803) <sup>5</sup> GB IRE

FAMILY POMATIIDAE Newton, 1891  
Pomatiasidae auct. partim  
Genus *Pomatias* Studer, 1789  
*Pomatias elegans* (Müller, 1774) GB IRE

FAMILY TRUNCATELLIDAE Gray, 1840  
Genus *Paludinella* L. Pfeiffer, 1841  
*Paludinella littorina* (delle Chiaje, 1828) GB

Genus *Truncatella* Risso, 1826  
*Truncatella subcylindrica* (Linnaeus, 1767) GB IRE

ORDER ECTOBRANCHIA FISCHER, 1884

FAMILY VALVATIDAE Thomson, 1840  
Genus *Valvata* Müller, 1773  
Subgenus *Cincinna* Férussac, 1821  
*Valvata piscinalis* (Müller, 1774) GB IRE

Subgenus *Tropidina* H. & A. Adams, 1854  
*Valvata macrostoma* Mörch, 1864 GB

Subgenus *Valvata* Müller, 1773  
*Valvata cristata* Müller, 1774 GB IRE

ORDER PULMONATA CUVIER IN BLAINVILLE, 1814

FAMILY ACROLOXIDAE Thiele, 1931  
Genus *Acroloxus* Beck, 1837  
*Acroloxus lacustris* (Linnaeus, 1758) GB IRE

FAMILY AGRIOLIMACIDAE Wagner, 1935  
Genus *Deroceras* Rafinesque, 1820  
Subgenus *Deroceras* Rafinesque, 1820  
*Deroceras agreste* (Linnaeus, 1758) GB

<i>Deroceras laeve</i> (Müller, 1774)	GB IRE
<i>Deroceras panormitanum</i> (Lessona & Pollonera, 1882)	GB IRE
<i>caruanae</i> (Pollonera, 1891)	
<i>Deroceras reticulatum</i> (Müller, 1774)	GB IRE

## FAMILY ARIONIDAE Gray in Turton, 1840

Genus *Arion* Férussac, 1819Subgenus *Arion* Férussac, 1819

<i>Arion ater</i> (Linnaeus, 1758)	GB IRE
<i>Arion flagellus</i> Collinge, 1893	GB IRE
<i>lusitanicus</i> auct. Brit. non Mabilie, 1868	
<i>Arion rufus</i> (Linnaeus, 1758) <sup>6</sup>	GB IRE
<i>Arion vulgaris</i> Moquin-Tandon, 1855 <sup>7</sup>	GB IRE
<i>lusitanicus</i> auct. non Mabilie, 1868	

Subgenus *Mesarion* Hesse, 1926

<i>Arion fuscus</i> (Müller, 1774) <sup>8</sup>	IRE
<i>Arion subfuscus</i> (Draparnaud, 1805)	GB IRE

Subgenus *Carinarion* Hesse, 1926

<i>Arion circumscriptus</i> Johnston, 1828	GB IRE
<i>Arion fasciatus</i> (Nilsson, 1823)	GB IRE
<i>Arion silvaticus</i> Lohmander, 1937	GB IRE

Subgenus *Kobeltia* Seibert, 1873

<i>Arion distinctus</i> Mabilie, 1868	GB IRE
<i>hortensis</i> auct. non Férussac, 1819	
<i>Arion hortensis</i> Férussac, 1819	GB IRE
<i>Arion intermedius</i> Normand, 1852	GB IRE
<i>Arion occultus</i> Anderson, 2004 <sup>9</sup>	IRE
<i>Arion owenii</i> Davies, 1979	GB IRE
<i>hortensis</i> auct. non Férussac, 1819	

Genus *Geomalacus* Allman, 1843

<i>Geomalacus maculosus</i> Allman, 1843	IRE
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## FAMILY AZECIDAE Watson, 1920

Genus *Azeca* Fleming, 1828

<i>Azeca goodalli</i> (Férussac, 1821)	GB
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## FAMILY BOETTGERILLIDAE Van Goethem, 1972

Genus *Boettgerilla* Simroth, 1910

<i>Boettgerilla pallens</i> Simroth, 1912	GB IRE
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## FAMILY BRADYBAENIDAE Pilsbry, 1934

Genus *Fruticicola* Held, 183

<i>Fruticicola fruticum</i> (Müller, 1774)	GB(E)
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## FAMILY CARYCHIIDAE Jeffreys, 1830

Genus *Carychium* Müller, 1773

<i>Carychium minimum</i> Müller, 1774	GB IRE
<i>Carychium tridentatum</i> (Risso, 1826)	GB IRE

## FAMILY CHONDRINIDAE Steenberg, 1925

Genus *Abida* Turton, 1831*Abida secale* (Draparnaud, 1801)

GB IRE

## FAMILY CLAUSILIIDAE J. E. Gray, 1855

Genus *Balea* Gray, 1824Subgenus *Alinda* H. & A. Adams, 1855*Balea biplicata* (Montagu, 1803)

GB

Subgenus *Balea* Gray, 1824*Balea perversa* (Linnaeus, 1758)

GB IRE

*Balea heydeni* Von Maltzan, 1881 <sup>10</sup>

GB IRE

Genus *Clausilia* Draparnaud, 1805Subgenus *Clausilia* Draparnaud, 1805*Clausilia bidentata* (Ström, 1765)

GB IRE

Subgenus *Andraea* L. Pfeiffer, 1848*Clausilia dubia* Draparnaud, 1805

GB

Genus *Cochlodina* Férussac, 1821Subgenus *Cochlodina* Férussac, 1821*Cochlodina laminata* (Montagu, 1803)

GB IRE

Genus *Macrogastra* Hartmann, 1841Subgenus *Pseudovestia* Nordsieck, 1977*Macrogastra rolphii* (Turton, 1826)

GB

FAMILY COCHLICELLIDAE Schileyko, 1972 <sup>11</sup>Genus *Cochlicella* Férussac, 1821Subgenus *Cochlicella* Férussac, 1821*Cochlicella acuta* (Müller, 1774)

GB IRE

Subgenus *Prietocella* Schileyko & Menkhorst, 1997 <sup>12</sup>*Cochlicella barbara* (Linnaeus, 1758)

GB

## FAMILY COCHLICOPIDAE Pilsbry, 1900 (1879)

Genus *Cochlicopa* Férussac, 1821 <sup>13</sup>*Cochlicopa* cf. *lubrica* (Müller, 1774)

GB IRE

*Cochlicopa* cf. *lubricella* (Rossmässler, 1834)

GB IRE

## FAMILY DISCIDAE Thiele, 1931

Genus *Discus* Fitzinger, 1833Subgenus *Gonyodiscus* Fitzinger, 1833*Discus rotundatus* (Müller, 1774)

GB IRE

## FAMILY ELLOBIIDAE H. &amp; A. Adams, 1854

Genus *Leucophytia* Winckworth, 1949*Leucophytia bidentata* (Montagu, 1808)

GB IRE

Genus *Myosotella* Monterosato, 1906 <sup>14</sup>*Ovatella* Bivona, 1832 partim*Myosotella denticulata* (Montagu, 1803) <sup>15</sup>

GB IRE

*Myosotella myosotis* (Draparnaud, 1801)

GB IRE



## FAMILY ENIDAE Woodward, 1903 (1880)

Genus *Ena* Turton, 1831*Ena montana* (Draparnaud, 1801) GBGenus *Merdigera* Held, 1838 <sup>16</sup>*Ena* Turton, 1831 auct.*Merdigera obscura* (Müller, 1774) GB IRE

## FAMILY EUCONULIDAE Baker, 1928

Genus *Euconulus* Reinhardt, 1883 <sup>17</sup>Subgenus *Euconulus* Reinhardt, 1883*Euconulus* cf. *alderi* (Gray, 1840) GB IRE*Euconulus* cf. *fulvus* (Müller, 1774) GB IRE

## FAMILY FERUSSACIIDAE Bourguignat, 1883

Genus *Cecilioides* Férussac, 1814Subgenus *Cecilioides* Férussac, 1814*Cecilioides acicula* (Müller, 1774) GB IRE

## FAMILY GASTRODONTIDAE Tryon, 1866

Genus *Zonitoides* Lehmann, 1862Subgenus *Zonitoides* Lehmann, 1862*Zonitoides nitidus* (Müller, 1774) GB IRESubgenus *Zonitellus* Baker, 1928*Zonitoides excavatus* (Alder, 1830) GB IRE

## FAMILY HELICIDAE Rafinesque, 1815

Genus *Arianta* Leach in Turton, 1831*Arianta arbustorum* (Linnaeus, 1758) GB IREGenus *Cepaea* Held, 1838Subgenus *Cepaea* Held, 1838*Cepaea nemoralis* (Linnaeus, 1758) GB IRE*Cepaea hortensis* (Müller, 1774) GB IREGenus *Cornu* Born, 1778*Helix* Linnaeus, 1758 partim*Cantareus* Risso, 1826*Cryptomphalus* Charpentier, 1837*Cornu aspersum* (Müller, 1774) <sup>18</sup> GB IREGenus *Helicigona* Férussac, 1821*Helicigona lapicida* (Linnaeus, 1758) GB IREGenus *Helix* Linnaeus, 1758Subgenus *Helix* Linnaeus, 1758*Helix pomatia* Linnaeus, 1758 GBGenus *Theba* Risso, 1826*Theba pisana* (Müller, 1774) GB IRE

FAMILY HELICODISCIDAE Baker, 1927	
Genus <i>Lucilla</i> Lowe, 1852	
<i>Helicodiscus</i> Morse, 1864 partim	
<i>Hebetodiscus</i> Baker, 1929	
<i>Lucilla singleyana</i> (Pilsbry, 1890) <sup>19</sup>	GB
FAMILY HELICODONTIDAE Kobelt, 1904	
Genus <i>Helicodonta</i> Férussac, 1821	
<i>Helicodonta obvoluta</i> (Müller, 1774)	GB
FAMILY HYGROMIIDAE Tryon, 1866	
Genus <i>Ashfordia</i> Taylor, 1917	
<i>Ashfordia granulata</i> (Alder, 1830)	GB IRE
Genus <i>Candidula</i> Kobelt, 1871	
<i>Candidula gigaxii</i> (L. Pfeiffer, 1850)	GB IRE
<i>Candidula intersecta</i> (Poiret, 1801)	GB IRE
Genus <i>Cernuella</i> Schlüter, 1838	
Subgenus <i>Cernuella</i> Schlüter, 1838	
<i>Cernuella aginnica</i> Locard, 1894 <sup>20</sup>	GB
<i>Cernuella virgata</i> (Da Costa, 1778)	GB IRE
Subgenus <i>Xerocincta</i> Monterosato, 1892	
<i>Cernuella neglecta</i> (Draparnaud, 1805)	GB(E)
Genus <i>Helicella</i> Férussac, 1821	
<i>Helicella itala</i> (Linnaeus, 1758)	GB IRE
Genus <i>Hygromia</i> Risso, 1826	
Subgenus <i>Hygromia</i> Risso, 1826	
<i>Hygromia cinctella</i> (Draparnaud, 1801)	GB IRE
Subgenus <i>Riedelia</i> Schileyko, 1972	
<i>Hygromia limbata</i> (Draparnaud, 1805)	GB
Genus <i>Monacha</i> Fitzinger, 1833	
Subgenus <i>Monacha</i> Fitzinger, 1833	
<i>Monacha cantiana</i> (Montagu, 1803)	GB
<i>Monacha cartusiana</i> (Müller, 1774)	GB
Genus <i>Ponentina</i> Hesse, 1921	
<i>Ponentina subvirescens</i> (Bellamy, 1839)	GB
Genus <i>Pseudotrichia</i> Likharev, 1949	
<i>Perforatella</i> Schlüter, 1838 partim	
<i>Pseudotrichia rubiginosa</i> (Rossmässler, 1838)	GB
Genus <i>Trochoidea</i> Brown, 1827	
Subgenus <i>Trochoidea</i> Brown, 1827	
<i>Trochoidea elegans</i> (Gmelin, 1791)	GB

Genus *Trochulus* Chemnitz, 1786 <sup>21</sup>*Trichia* Hartmann, 1840 non de Haan, 1839 [Crustacea, Brachyura] <sup>\*\*</sup>Subgenus *Trochulus* Chemnitz, 1786*Trochulus hispidus* (Linnaeus, 1758)

GB IRE

*Trochulus sericeus* (Draparnaud, 1801) <sup>22</sup>

GB

*plebeius* auct. non (Draparnaud, 1805)*Trochulus striolatus* (C. Pfeiffer, 1828)

GB IRE

Genus *Zenobiella* Gude & Woodward, 1921*Perforatella* Schlüter, 1838 partim <sup>23</sup>*Zenobiella subrufescens* (Miller, 1822)

GB IRE

## FAMILY LAURIIDAE Steenberg, 1925

Genus *Lauria* Gray in Turton, 1840Subgenus *Lauria* Gray in Turton, 1840*Lauria cylindracea* (Da Costa, 1778)

GB IRE

*Lauria sempronii* (Charpentier, 1837)

GB

Genus *Leiostyla* Lowe, 1852Subgenus *Leiostyla* Lowe, 1852*Leiostyla anglica* (Férussac, 1821)

GB IRE

## FAMILY LIMACIDAE Lamarck, 1801

Genus *Lehmannia* Heynemann, 1863*Limax* L., 1758, partim*Lehmannia marginata* (Müller, 1774)

GB IRE

*Lehmannia nyctelia* (Bouguignat, 1861) <sup>24</sup>

GB

*Lehmannia valentiana* (Férussac, 1822)

GB IRE

Genus *Limacus* Lehmann, 1864*Limax* L., 1758 partim*Limacus flavus* (Linnaeus, 1758)

GB IRE

*Limacus maculatus* (Kaleniczenko, 1851) <sup>25</sup>

GB IRE

*pseudoflavus* (Evans, 1978)Genus *Limax* Linnaeus, 1758*Limax cinereoniger* Wolf, 1803

GB IRE

*Limax maximus* Linnaeus, 1758

GB IRE

Genus *Malacolimax* Malm, 1868*Malacolimax tenellus* (Müller, 1774)

GB

## FAMILY LYMNAEIDAE Rafinesque, 1815

Genus *Galba* Schrank, 1803*Lymnaea* Lamarck, 1799 partim*Galba truncatula* (Müller, 1774)

GB IRE

Genus *Lymnaea* Lamarck, 1799Subgenus *Lymnaea* s.s.*Lymnaea stagnalis* (Linnaeus, 1758)

GB IRE

<sup>\*\*</sup> Opinion 2079, ICZN: *Trichia* Hartmann, 1840 (Mollusca, Gastropoda): proposed conservation; not approved because of homonymy with *Trichia* de Haan, 1839 [Crustacea, Brachyura]; replaced by *Trochulus* Chemnitz, 1786.



Subgenus <i>Stagnicola</i> Jeffreys, 1830 <sup>26</sup>	
<i>Lymnaea fusca</i> (C. Pfeiffer, 1821) <sup>27</sup>	GB IRE
<i>palustris</i> (Müller, 1774) auct. partim	
<i>Lymnaea palustris</i> (Müller, 1774)	GB
Genus <i>Myxas</i> Sowerby, 1822	
<i>Myxas glutinosa</i> (Müller, 1774)	GB IRE
Genus <i>Omphiscola</i> Beck, 1837	
<i>Lymnaea</i> Lamarck, 1799 partim	
<i>Omphiscola glabra</i> (Müller, 1774)	GB IRE
Genus <i>Radix</i> Montfort, 1810	
<i>Lymnaea</i> Lamarck, 1799 partim	
<i>Radix auricularia</i> (Linnaeus, 1758)	GB IRE
<i>Radix balthica</i> (Linnaeus, 1758) <sup>28</sup>	
<i>peregra</i> (Müller, 1774)	
<i>ovata</i> (Müller, 1774)	
FAMILY MILACIDAE Ellis, 1926	
Genus <i>Milax</i> Gray, 1855	
<i>Milax gagates</i> (Draparnaud, 1801)	GB IRE
Genus <i>Tandonia</i> Lessona & Pollonera, 1882	
<i>Milax</i> Gray, 1855 partim	
<i>Tandonia budapestensis</i> (Hazay, 1881)	GB IRE
<i>Tandonia rustica</i> (Millet, 1843)	GB IRE
<i>Tandonia sowerbyi</i> (Férussac, 1823)	GB IRE
FAMILY ONCHIDIIDAE Rafinesque, 1815	
Genus <i>Onchidella</i> Gray, 1850	
<i>Onchidella celtica</i> (Cuvier, 1817)	GB
FAMILY OTINIDAE H. & A. Adams, 1855	
Genus <i>Otina</i> Gray, 1847	
<i>Otina ovata</i> (Brown, 1827)	GB IRE
FAMILY OXYCHILIDAE Hesse 1927 (1879)	
Genus <i>Aegopinella</i> Lindholm, 1927	
<i>Aegopinella pura</i> (Alder, 1830)	GB IRE
<i>Aegopinella nitidula</i> (Draparnaud, 1805)	GB IRE
Genus <i>Nesovitrea</i> Cooke, 1921	
Subgenus <i>Perpolita</i> Baker, 1928	
<i>Nesovitrea hammonis</i> (Ström, 1765)	GB IRE
Genus <i>Oxychilus</i> Fitzinger, 1833	
Subgenus <i>Oxychilus</i> Fitzinger, 1833	
<i>Oxychilus alliarius</i> (Miller, 1822) <sup>29</sup>	GB IRE
<i>Oxychilus cellarius</i> (Müller, 1774)	GB IRE
<i>Oxychilus draparnaudi</i> (Beck, 1837)	GB IRE

- Oxychilus navarricus* (Bouguignat, 1870)  
*s. helveticus* (Blum, 1881) <sup>30</sup> GB IRE
- FAMILY PHYSIDAE Fitzinger, 1833  
 Genus *Aplexa* Fleming, 1828  
*Aplexa hypnorum* (Linnaeus, 1758) GB IRE
- Genus *Physa* Draparnaud, 1801  
*Physa fontinalis* (Linnaeus, 1758) GB IRE
- Genus *Physella* Haldeman, 1843 <sup>31</sup>  
*Physa* Draparnaud auct.  
*Physella acuta* (Draparnaud, 1805) <sup>32</sup> GB IRE  
*heterostropha* (Say, 1817)  
*Physella gyrina* (Say, 1821) GB IRE
- FAMILY PLANORBIDAE Rafinesque, 1815  
 Genus *Ancylus* Müller, 1773  
*Ancylus fluviatilis* Müller, 1774 GB IRE
- Genus *Anisus* Studer, 1820  
 Subgenus *Anisus* Studer, 1820  
*Anisus leucostoma* (Millet, 1813) GB IRE  
*septemgyratus* sensu Falkner *et al.* (2001)  
*Anisus spirorbis* (L., 1758) <sup>33</sup> GB IRE
- Subgenus *Disculifer* Boettger, 1944  
*Anisus vortex* (Linnaeus, 1758) GB IRE  
*Anisus vorticulus* (Troschel, 1834) GB
- Genus *Bathyomphalus* Charpentier, 1837  
*Bathyomphalus contortus* (Linnaeus, 1758) GB IRE
- Genus *Ferrissia* Walker, 1903  
*Ferrissia wautieri* (Mirolli, 1960) <sup>34</sup> GB
- Genus *Gyraulus* Charpentier, 1837  
 Subgenus *Armiger* Hartmann, 1840  
*Gyraulus crista* (Linnaeus, 1758) GB IRE
- Subgenus *Gyraulus* Charpentier, 1837  
*Gyraulus albus* (Müller, 1774) GB IRE
- Subgenus *Torquis* Dall, 1905  
*Gyraulus acronicus* (Férussac, 1807) GB  
*Gyraulus laevis* (Alder, 1838) GB IRE
- Genus *Hippeutis* Charpentier, 1837  
*Hippeutis complanatus* (Linnaeus, 1758) GB IRE
- Genus *Menetus* H. & A. Adams, 1855  
*Menetus dilatatus* (Gould, 1841) GB

Genus <i>Planorbarius</i> Duméril, 1806	
<i>Planorbarius corneus</i> (Linnaeus, 1758)	GB IRE
Genus <i>Planorbis</i> Müller, 1773	
<i>Planorbis planorbis</i> (Linnaeus, 1758)	GB IRE
<i>Planorbis carinatus</i> Müller, 1774	GB IRE
Genus <i>Segmentina</i> Fleming, 1818	
<i>Segmentina nitida</i> (Müller, 1774)	GB
FAMILY PRISTILOMATIDAE Cockerell, 1891	
Genus <i>Vitrea</i> Fitzinger, 1833	
<i>Vitrea contracta</i> (Westerlund, 1871)	GB IRE
<i>Vitrea crystallina</i> (Müller, 1774)	GB IRE
<i>Vitrea subrimata</i> (Reinhardt, 1871)	GB
FAMILY PUNCTIDAE Morse, 1864	
Genus <i>Paralaoma</i> Iredale, 1913	
<i>Paralaoma servilis</i> (Shuttleworth, 1852) <sup>35</sup>	GB
<i>caputspinulae</i> (Reeve, 1852)	
<i>micropleuros</i> (Paget, 1854)	
<i>pusilla</i> Lowe, 1831 non Vallot, 1801	
Genus <i>Punctum</i> Morse, 1864	
Subgenus <i>Punctum</i> Morse, 1864	
<i>Punctum pygmaeum</i> (Draparnaud, 1801)	GB IRE
FAMILY PUPILLIDAE Turton, 1831	
Genus <i>Pupilla</i> Fleming, 1828	
Subgenus <i>Pupilla</i> Fleming, 1828	
<i>Pupilla muscorum</i> (Linnaeus, 1758) <sup>36</sup>	GB IRE
FAMILY PYRAMIDULIDAE Kennard & Woodward, 1914	
Genus <i>Pyramidula</i> Fitzinger, 1833	
<i>Pyramidula pusilla</i> (Vallot, 1801) <sup>37</sup>	GB IRE
<i>rupestris</i> (Draparnaud, 1801) auct. partim	
FAMILY SUCCINEIDAE Beck, 1837	
Genus <i>Oxyloma</i> Westerlund, 1885	
Subgenus <i>Oxyloma</i> Westerlund, 1885	
<i>Oxyloma elegans</i> (Risso, 1826) <sup>38</sup>	GB IRE
<i>pfeifferi</i> (Rossmässler, 1835)	
<i>Oxyloma sarsi</i> (Esmark, 1886)	GB IRE
<i>elegans</i> auct. Brit. non (Risso, 1826)	
Genus <i>Quickella</i> Boettger, 1939	
<i>Catinella</i> Odhner, 1950 partim	
<i>Quickella arenaria</i> (Potiez & Michaud, 1835)	GB IRE
Genus <i>Succinea</i> Draparnaud, 1801	
<i>Succinea putris</i> (Linnaeus, 1758)	GB IRE



Genus *Succinella* Mabilie, 1870*Succinea* Draparnaud, 1801 partim*Succinella oblonga* Draparnaud, 1801

GB IRE

## FAMILY TESTACELLIDAE Gray, 1840

Genus *Testacella* Cuvier, 1800Subgenus *Testacella* Cuvier, 1800*Testacella haliotidea* Draparnaud, 1801

GB IRE

*Testacella maugei* Férussac, 1819

GB IRE

*Testacella scutulum* Sowerby, 1820

GB IRE

## FAMILY VALLONIIDAE Pilsbry, 1900

Genus *Acanthinula* Beck, 1847*Acanthinula aculeata* (Müller, 1774)

GB IRE

Genus *Spermodea* Westerlund, 1903*Spermodea lamellata* (Jeffreys, 1830)

GB IRE

Genus *Vallonia* Risso, 1826*Vallonia costata* (Müller, 1774)

GB IRE

*Vallonia* cf. *excentrica* Sterki, 1893 <sup>39</sup>

GB IRE

*Vallonia pulchella* (Müller, 1774)

GB IRE

## FAMILY VERTIGINIDAE Fitzinger, 1833

Genus *Columella* Westerlund, 1878*Columella aspera* Waldén, 1966

GB IRE

*Columella edentula* (Draparnaud, 1805)

GB IRE

Genus *Truncatellina* Lowe, 1852*Truncatellina callicratis* (Scacchi, 1833)

GB

*Truncatellina cylindrica* (Férussac, 1807) <sup>40</sup>

GB

Genus *Vertigo* Müller, 1773Subgenus *Vertigo* Müller, 1773*Vertigo alpestris* (Alder, 1838)

GB

*Vertigo antivertigo* (Draparnaud, 1801)

GB IRE

*Vertigo genesii* (Gredler, 1856)

GB

*Vertigo geyeri* Lindholm, 1925

GB IRE

*Vertigo lilljeborgi* (Westerlund, 1871)

GB IRE

*Vertigo modesta* (Say, 1824)

GB

*Vertigo moulinsiana* (Dupuy, 1849)

GB IRE

*Vertigo pusilla* Müller, 1774

GB IRE

*Vertigo pygmaea* (Draparnaud, 1801)

GB IRE

*Vertigo substriata* (Jeffreys, 1833)

GB IRE

Subgenus *Vertilla* Moquin-Tandon, 1856*Vertigo angustior* Jeffreys, 1830

GB IRE

## FAMILY VITRINIDAE Fitzinger, 1833

Genus *Phenacolimax* Stabile, 1859*Phenacolimax major* (Férussac, 1807)

GB

Genus <i>Semilimax</i> Stabile, 1859	
<i>Semilimax pyrenaicus</i> (Férussac, 1821)	IRE
Genus <i>Vitrina</i> Draparnaud, 1801	
<i>Vitrina pellucida</i> (Müller, 1774)	GB IRE

CLASS BIVALVIA LINNAEUS, 1758

ORDER UNIONOIDA STOLICZKA, 1870

FAMILY MARGARITIFERIDAE Henderson, 1929	
Genus <i>Margaritifera</i> Schumacher, 1816	
Subgenus <i>Margaritifera</i> Schumacher, 1816	
<i>Margaritifera margaritifera</i> (Linnaeus, 1758)	GB IRE
FAMILY UNIONIDAE Rafinesque, 1820	
Genus <i>Anodonta</i> Lamarck, 1799	
Subgenus <i>Anodonta</i> Lamarck, 1799	
<i>Anodonta anatina</i> (Linnaeus, 1758)	GB IRE
<i>Anodonta cygnea</i> (Linnaeus, 1758)	GB IRE
Genus <i>Pseudanodonta</i> Bourguignat, 1877	
<i>Pseudanodonta complanata</i> (Rossmässler, 1835)	GB
Genus <i>Unio</i> Philipsson, 1788	
Subgenus <i>Unio</i> Philipsson, 1788	
<i>Unio pictorum</i> (Linnaeus, 1758)	GB
<i>Unio tumidus</i> Philipsson, 1788	GB

ORDER VENEROIDA H. & A. ADAMS, 1856

FAMILY CORBICULIDAE	
Genus <i>Corbicula</i> von Mühlfeld, 1811	
<i>Corbicula fluminea</i> (Müller, 1774)	GB
FAMILY DREISSENIDAE Gray in Turton, 1840	
Genus <i>Dreissena</i> van Beneden, 1835	
Subgenus <i>Dreissena</i> van Beneden, 1835	
<i>Dreissena polymorpha</i> (Pallas, 1771)	GB IRE
Genus <i>Mytilopsis</i> Conrad, 1858	
<i>Mytilopsis leucophaeta</i> (Conrad, 1831)	GB
FAMILY SPHAERIIDAE DESHAYES, 1855 <sup>41</sup>	
Genus <i>Musculium</i> Link, 1807	
<i>Musculium lacustre</i> (Müller, 1774)	GB IRE
<i>Musculium transversum</i> (Say, 1829)	GB

Genus *Pisidium* C. Pfeiffer, 1821

<i>Pisidium amnicum</i> (Müller, 1774)	GB IRE
<i>Pisidium casertanum</i> (Poli, 1791)	GB IRE
<i>Pisidium conventus</i> Clessin, 1877	GB IRE
<i>Pisidium henslowanum</i> (Sheppard, 1823)	GB IRE
<i>Pisidium hibernicum</i> Westerlund, 1894	GB IRE
<i>Pisidium lilljeborgii</i> Clessin, 1866	GB IRE
<i>Pisidium milium</i> Held, 1836	GB IRE
<i>Pisidium moitessierianum</i> Paladilhe, 1866	GB IRE
<i>Pisidium nitidum</i> Jenyns, 1832	GB IRE
<i>Pisidium obtusale</i> (Lamarck, 1818)	GB IRE
<i>Pisidium personatum</i> Malm, 1855	GB IRE
<i>Pisidium pseudosphaerium</i> Schlesch, 1947	GB IRE
<i>Pisidium pulchellum</i> Jenyns, 1832	GB IRE
<i>Pisidium subtruncatum</i> Malm, 1855	GB IRE
<i>Pisidium supinum</i> A. Schmidt, 1851	GB
<i>Pisidium tenuilineatum</i> Stelfox, 1918	GB

Genus *Sphaerium* Scopoli, 1777

<i>Sphaerium corneum</i> (Linnaeus, 1758)	GB IRE
<i>Sphaerium nucleus</i> (Studer, 1820) <sup>42</sup>	GB IRE
<i>Sphaerium rivicola</i> (Lamarck, 1818)	GB
<i>Sphaerium solidum</i> (Normand, 1844)	GB

HOTHOUSE ALIENS

CLASS GASTROPODA CUVIER, 1795

ORDER NEOTAENIOGLOSSA HALLER, 1892

FAMILY THIARIDAE TROSCHER, 1857

Genus *Melanoides* Olivier, 1804

<i>Melanoides tuberculatus</i> (Müller, 1774)	GB IRE
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ORDER PULMONATA CUVIER IN BLAINVILLE, 1814

FAMILY GASTRODONTIDAE TRYON, 1866

Genus *Zonitoides* Lehmann, 1862

Subgenus *Zonitellus* Baker, 1928

<i>Zonitoides arboreus</i> (Say, 1816)	GB IRE
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FAMILY HELICODISCIDAE BAKER, 1927

Genus *Helicodiscus* Morse, 1864

<i>Helicodiscus parallelus</i> (Say, 1821)	GB IRE
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FAMILY LYMNAEIDAE RAFINESQUE, 1815

Genus *Radix* Montfort, 1810

<i>Radix rubiginosa</i> (Michelin, 1831) <sup>43</sup>	GB IRE
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FAMILY PLANORBIDAE GRAY IN TURTON, 1840		
Genus <i>Gyraulus</i> Charpentier, 1837		
Subgenus <i>Torquis</i> Dall, 1905		
<i>Gyraulus chinensis</i> (Dunker, 1848) <sup>44</sup>		GB IRE
Genus <i>Planorbella</i> Haldeman, 1842		
<i>Planorbella duryi</i> (Wetherby, 1879) <sup>45</sup>		GB IRE
FAMILY PLEURODISCIDAE WENZ, 1923		
Genus <i>Pleurodiscus</i> Wenz, 1919		
<i>Pleurodiscus balmei</i> (Potiez & Michaud, 1838)		GB IRE
FAMILY STREPTAXIDAE		
Genus <i>Gulella</i> Hutton, 1834		
<i>Gulella io</i> Verdcourt, 1974		GB
FAMILY SUBULINIDAE FISCHER & CROSSE, 1877		
Genus <i>Allopeas</i> Baker, 1935		
<i>Lamellaxis</i> Strebel & Pfeiffer, 1882 partim		
<i>Allopeas clavulinum</i> (Potiez & Michaud, 1838)		GB IRE
Genus <i>Opeas</i> Albers, 1850		
<i>Opeas hannensis</i> (Rang, 1831)		GB IRE
<i>pumilum</i> (L. Pfeiffer, 1840)		
Genus <i>Rumina</i> Risso, 1826		
<i>Rumina decollata</i> (Linnaeus, 1758) <sup>46</sup>		GB
Genus <i>Striosubulina</i> Thiele, 1933		
<i>Subulina</i> Beck, 1937 partim		
<i>Striosubulina</i> sp. <sup>47</sup>		GB
<i>striatella</i> auct. ?non (Rang, 1831)		
Genus <i>Subulina</i> Beck, 1837		
<i>Subulina octona</i> (Bruguière, 1789)		GB IRE
FAMILY ZONITIDAE MÖRCH, 1864		
Genus <i>Hawaiiia</i> Gude, 1911		
<i>Hawaiiia minuscula</i> (Binney, 1840)		GB IRE

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## EXCLUDED SPECIES

Some of the species listed for Britain or Ireland in Clecom have had to be excluded from the present list for the reasons given below.

*Lymnaea corva* (Gmelin, 1791)  
Despite its inclusion on the Clecom List for both Britain and Ireland, there is no evidence that this species occurs in our area. See Note 7.

*Monachoides incarnatus* (Müller, 1774)

This species is listed for Ireland by Falkner et al. (2001). I have seen immature shells belonging to this species said to have been collected near Clonmacnoise, Co. Offaly (fide Gerhard Falkner). Visits to the site in 2002, and subsequently, have failed to provide firm evidence for this species' occurrence in Ireland (pers. comm. of E. Moorkens). *Monachoides incarnatus* would not be expected in Ireland on biogeographical grounds as its range does not extend to either coastal north-west Europe or to Britain. It is excluded from the list until further evidence can be brought to bear.

*Milax nigricans* (Philippi, 1836)

In Britain and Ireland very dark coloured *Milax*, superficially similar to this species are occasionally encountered. I have dissected a number but so far all have proved to be *M. gagates* on the structure of the genital stimulator which is relatively smooth in *gagates* but moderately to strongly papillate in *nigricans*. Quick (1960) refers to the capture of a specimen of *M. nigricans* (det. H. Watson) from a garden at Bexhill, Sussex in 1948. There is no evidence for its establishment in this area and no subsequent reports from elsewhere, so it is excluded from the List.

*Sphaerium ovale* (Férusac, 1807)

See note 41.

*Valvata macrostoma* Mörch, 1864

Regarding the exclusion of this species from the Irish part of the List, there is a reference in Ross (1984) to specimens collected by William Thompson and labelled "Lough Neagh". These are housed in the Ulster Museum Collection. A.W. Stelfox and A.S. Kennard made the determinations so the identity of the collection is not in question but, as the determiners state, "locality doubtful". The Clecom List (Falkner et al. 2001) and that of Moorkens & Speight (2001) include this species for Ireland based on specimens collected in the floodplain of the R. Shannon near Clonmacnoise (pers. comm. of E. Moorkens). Thus far, it has not been possible to verify these claims.

## NOTES

1 *Hydrobia acuta neglecta*. Until recently this was regarded as a north-west European endemic, *Hydrobia neglecta* Muus (e.g. Kerney 1999). Giusti et al. (1995) suggested that it was very closely related to the Mediterranean taxon *H. acuta* and Hoeksema (1998) concluded that a Biscayan population was synonymous with *acuta*. In the Clecom List (Falkner et al. 2001) the specific epithet *neglecta* Muus was retained and the species placed in a separate genus *Obrovia* Radoman 1973. Wilke et al. (2000), however, found only small genetic differences between study populations in the western Mediterranean and north-west Europe and concluded that both should be referred to *Hydrobia acuta*, with the north-west populations distinguished only at the subspecific level i.e. as *Hydrobia acuta* s. *neglecta*. The generic name *Obrovia* was erected for Balkan material collected by Radoman (1973, 1977). Its use for *neglecta* has been justified in a rather pedantic way by Falkner et al. (2002) but has not been followed by Glöer (2002), and Davis (2004) has commented upon the tendency of authors of the Clecom List to ignore relevant molecular studies. Its use is certainly fundamentally at odds with current phylogenetic evidence and is disregarded here.

2 *Marstoniopsis insubrica*. The name here is changed from the traditional usage, *M. scholtzi*, because of recent work by Falniowski & Wilke (2001). These authors compared

*M. scholtzi* with a south alpine taxon, *M. insubrica*, and could find no significant morphological or genetic differences. The name *insubrica* must be substituted on date priority.

3 *Mercuria* cf. *similis*. The name for the British and Irish species of *Mercuria*, previously designated *M. confusa* (Frauenfeld, 1863), is uncertain. The types of *confusa* have locality data, "*Gallia meridionalis*", which indicate that they refer to a Mediterranean taxon. Indeed, Boeters & Falkner (2000) have used the locality designation and similarity of the types to material from southern France (Camargue) to justify the use of *confusa* lectotypes as neotypes of the Mediterranean species from that area, namely *M. similis* (Draparnaud, 1805). This had hitherto lacked types. Falkner *et al.* (2002) further make a case for calling the N. European taxon *anatina* (Poiret, 1801). Phylogenetic analysis of *Mercuria* is clearly desirable, as some authors (e.g. Giusti (1979)) suggest that there is only one variable species of *Mercuria* in the Mediterranean, rather than the large number of putative taxa recognised by others (e.g. Falkner *et al.* 2002). Indeed the N. European species may be conspecific with the Mediterranean *similis*, differences being at the subspecies level only, as is the case with populations of *Hydrobia acuta* in Europe.

A real difficulty with the position of Falkner *et al.* (2001, 2002) is that the type locality of *anatina* is uncertain and that the type is teratological. Nor is there any certainty that the Mediterranean and N. European populations are genetically distinct. It is preferable to await the results of phylogenetic analysis and leave the name conditional, as *Mercuria* cf. *similis*.

4 *Peringia ulvae*. Wilke *et al.* (2000), and the Clecom List are followed here, in placing *ulvae* within *Peringia* Paladilhe.

5 *Ventrosia ventrosa*. The use of a separate genus to distinguish this species is contentious. Haase (1993) considered this to be unjustified on genetic distance criteria. However, Wilke *et al.* (2000), in an ongoing phylogenetic study of *Hydrobia* s. l. in Europe, demonstrated the existence of three distinct clades in European *Hydrobia* s.l. represented by the genera: *Hydrobia* s.s., *Peringia* Paladilhe and *Ventrosia* Radoman. Their conclusions are accepted here.

6 *Arion rufus*. Quick (1960) gives a detailed account of the red *Arion* found in Britain which he referred to *Arion rufus* (L.). Altena (1963) confirmed this designation as Linnaeus had cited drawings of Yorkshire specimens described by Lister (1685) and these were clearly identifiable with Quick's slug. Altena had pursued this issue as Odhner (1951) had inferred that Linnaeus' species was synonymous with *Arion subfuscus* (Drap.) The name to be applied to Quick's species in that case would have been *Arion empiricorum* Férussac 1819. What neither Altena (1963) nor Quick (1960) realised, was that *empiricorum*, rather than a synonym of *rufus* (L.), is in all likelihood a distinct species in its own right (pers. comm. of S. M. Davies). The descriptions of Continental 'rufus' by Chevallier (1981) should be compared with Quick's description of the Linnean species (1960). It appears that the Linnean taxon is confined to Britain, Ireland and Fennoscandia whereas a separate species occurs in continental areas of western Europe.

7 *Arion vulgaris*. The name *Arion lusitanicus* can no longer be applied to this taxon. A recent re-description of *lusitanicus* sensu Mabilie, based on topotypes from Setúbal, Serra da Arrábida, Portugal (Castillejo 1997) has shown that Portuguese *lusitanicus* has a very different spermatophore and internal morphology from the central and west European species to which this name was applied, first by Altena (1956) and then by



subsequent authors. Falkner *et al.* (2002) have proposed that the north-west European species be called *vulgaris* Moquin-Tandon, 1855 as this is the first name which can be unambiguously applied. This argument is followed here.

British authors including Quick (1960) confused *vulgaris* with *Arion flagellus* Collinge. Some of Quick's drawings of '*lusitanicus*' (= *vulgaris*), particularly of the spermatophore, actually relate to *flagellus*. The reader is directed to Davies' (1987) paper which first resolved the confusion here and gives a detailed account of the distinguishing features and reproductive biology of both species.

**8 *Arion fuscus/subfuscus*.** The name *Arion subfuscus* has been placed in synonymy with *Arion fuscus* by Falkner *et al.* (2001) for north European populations of this taxon. Draparnaud's species (*subfuscus*), with type locality in the Massif Central, was recently re-described by Garrido *et al.* (1995) from topotypic material and Falkner *et al.* (2001) claim that this is a southern species distinct from the common north European taxon. As a result the north European taxon requires a replacement name, now given as *A. fuscus* (Müller). However, Wiktor (1973) found great variability both internally and externally in Polish examples of *subfuscus* s.l., and has re-iterated recently that in Europe only one variable species is involved (Wiktor 2001).

Pinceel *et al.* (2004) have recently entered the fray using genetic analysis. Their results confirm that at least two distinct taxa, within *A. subfuscus* s.l., are present in north-west Europe. British Isles material was not examined directly by them but the results of Foltz *et al.* (1982) indicate that a form of *subfuscus* s.s. is present here. Most of the material collected by Pinceel *et al.* (2004) from the north-west seaboard of Europe (Scandinavia, north Holland, north Germany), however, is referable to the second species, *Arion fuscus*. This makes it highly probable that *A. fuscus* will occur at least in northern parts of the British Isles. I have reviewed some alcohol vouchers from both Britain and Ireland and find the *A. subfuscus* morphotype, identified on the ovotestis characters of Pinceel *et al.* (2004), to be dominant. Only a single specimen was unambiguously attributed to the *A. fuscus* morphotype, collected on Knockmore Mountain, Clare Island, Co. Galway in October 2002. *Arion fuscus* is therefore added to the List alongside *A. subfuscus* s.s. There appear to be no reliable external features distinguishing these taxa, but the ovotestis has a diagnostic morphology (Pinceel *et al.* 2004) and is relatively easy to examine.

**9 *Arion occultus*.** This species was recently described from Ireland (Anderson 2004). *Arion occultus* is almost certainly an introduction but the country of origin is unknown and it is recorded from only a small area in Co. Down. It is placed within the *Arion hortensis* group of *Kobeltia*, and is closely allied to *Arion distinctus*.

**10 *Balea heydeni*.** Preece & Gittenberger (2003) have introduced *Balea heydeni* as a valid species, distinct from *Balea perversa*, and occurring in the islands of the eastern Atlantic. It is clear that both *Balea heydeni* and *B. perversa* occur in Britain and Ireland (B. Colville, pers. comm.) but the issue needs to be more fully resolved by phylogenetic work. Such work is apparently in progress (pers. comm. of R. Preece).

**11 *Cochlicellidae*.** The molecular data of Steinke *et al.* (2004) suggest that *Cochlicella* is rather distantly related to other genera in the Hygromiidae and is closer to the Sphincterochilidae. This coincides with the conclusions of Schileyko & Menkhurst (1997) using anatomical data. *Cochlicella* is therefore placed in a separate family, the Cochlicellidae.

**12 *Cochlicella barbara*.** Schileyko and Menkhurst (1997) have separated *barbara* (L.)

from the other two *Cochlicella* on the structure of the penial papilla. Their preferred ordination is the erection of a new genus *Prietocella*. However, Falkner *et al.* (2001) have introduced this name at the subgeneric level. Falkner *et al.* (2001) is followed here.

13 *Cochlicopa lubrica/lubricella*. The taxonomy of *Cochlicopa* in Europe is difficult and confused. Falkner *et al.* (2001, 2002) recognise four taxa: *C. lubrica*; *C. lubricella*; *C. repentina*; *C. nitens*. Armbruster (2002) mentions a fifth, *C. lohmanderi* Waldén, 2001 from Sweden. *Cochlicopa lubrica*, *C. lubricella* and *C. repentina* are listed as British by Falkner *et al.* (2001). The inclusion of *C. repentina* is controversial and this species has not been recognised by British and Irish authors other than Moorkens & Speight (2001). The distinguishing features are primarily conchological (Waldén 1976), and analysis by Armbruster (2002) has indicated that *repentina* is synonymous with *C. lubrica*.

The reliable distinction of *C. lubrica* and *C. lubricella* in the field is also uncertain, as phylogenetic analysis (Armbruster 1997) has indicated that *lubrica* exists as two distinct ecotypes, one found in damp habitats, the other in dry, exposed places and that *lubricella* comprises two small-shelled paraphyletic taxa, distinguishable only on genetic characters. One of the *lubricella* taxa closely approaches *C. lubrica* and may be synonymous. It is likely that both *C. lubrica* and *C. lubricella* occur in Britain and Ireland, but the usual distinguishing features, shell size and habitat preference, are probably unreliable. For these reasons the species are listed as *Cochlicopa* cf. *lubrica* and *C. cf. lubricella* in recognition of the unreliable nature of the relationship between shell morphology and the biological species and the fact that British material has not been compared directly with topotypic Continental material to which these names apply.

14 *Myosotella*. *Ovatella* is now split into two genera, *Ovatella* s.s. and *Myosotella*, the latter name applying to the British and Irish species (Martens 1999).

15 *Myosotella denticulata*. *Myosotella denticulata* is recognised in the Clecom List as distinct from *M. myosotis* and as occurring in our area. An ecological distinction from *myosotis* is claimed, with *M. denticulata* occupying more fully marine environments. Intermediates between the two do occur, however, and I have seen such on the west coast of Ireland. Despite this, *denticulata* is included in the List, the contrary evidence being rather sparse and anecdotal. Its inclusion will also enable Conchological Society members to plot its distribution and help elucidate postulated ecological preferences.

16 *Merdigera obscura*. This was formerly included within *Ena*, chiefly on shell characters. A re-evaluation of its affinities (Schileyko 1978) has concluded that it is not very closely related to the other British species, *Ena montana* (tribe *Enini*), and is now placed in *Merdigera* within a different tribe, the *Multidentulini*.

17 *Euconulus* cf. *fulvus/alderi*. Falkner *et al.* (2001), in what they describe as the preliminary phase of a revision of European *Euconulus* (Falkner *et al.* 2002), list three taxa for Britain and Ireland: *E. fulvus*; *E. trochiformis* (Montagu, 1803); and *E. praticola* (Reinhardt, 1883). *Euconulus trochiformis* is claimed as a senior synonym of *E. alderi* and therefore replaces that name, and *E. praticola* represents a third taxon distinguished from the others on large shell size, dark shell colour, and very dark animal with a stenotopic habit, being confined mainly to wetlands.

There are several problems with these proposals in respect of the fauna of Britain and Ireland. The current ordination for the British Isles fauna i.e. using *E. fulvus* and *E. alderi*, has a lot of data attached. Two forms are generally recognisable in the field i.e. a relatively large, dull form with pale animal occurring in shaded habitats (*E. fulvus*), and a smaller, more glossy form with darker animal (though varying in body colour) in open,

wet habitats (*E. cf. alderi*). It is difficult to see where the third taxon, *praticola*, fits in. A small, pale-bodied form is occasional in wetland biotopes but does not fit into Falkner's ordination, whereas there is little evidence for a larger, dark animal (*praticola*) such as he describes. The full details of the proposed revision of *Euconulus* are unavailable so I regard it as premature to accept an orthodoxy lacking published justification. In order to bridge the divide between the Clecom view and the view of field recorders in Britain I have chosen to retain the familiar names but apply a conditional stance i.e. *cf. fulvus* and *cf. alderi*.

18 *Cornu aspersum*. The generic name for the common garden snail has been a source of controversy for some time. At least three alternatives are circulating in the literature, including *Cantareus* Risso and *Cryptomphalus* Charpentier, which are now generally applied to species in different helicid clades from *aspersa*. The name *Cornu* Born has been applied by Falkner *et al.* (2001), although the type is a scalariform (teratological) specimen. This makes *Cornu* unavailable according to ICZN Article 1B(2) (1985) but it has been argued that its validity is unaffected because it was described or designated in Born's protologue as teratological. Waldén (1976) appeared to accept this or a similar argument in an earlier list for Britain and Ireland, in placing the garden snail in *Helix* subgenus *Cornu*.

19 *Lucilla singleyana*. This taxon, listed by Kerney (1999) as *Helicodiscus singleyanus*, was placed in subgenus *Hebetodiscus* by Pilsbry (1948). Falkner *et al.* (2002) make a case for regarding *Hebetodiscus* as distinct at the generic level from *Helicodiscus*. Since *Lucilla* Lowe, 1852, applied to material of *singleyanus* from Madeira, has date priority over *Hebetodiscus* Baker, 1929, the generic name should be *Lucilla*, and the species name *singleyana*.

20 *Cernuella aginnica*. Added to the British List by Carr (2002) from near Maidstone in Kent.

21 *Trochulus*. A recent ICZN ruling, Opinion 2079 (2004), has resulted in the replacement of the name *Trichia* Hartmann, 1840 for the hairy snail and related species, to remove homonymy with *Trichia* de Haan, 1839 (Crustacea, Brachyura) relating to marine crabs. The replacement name is *Trochulus* Chemnitz, 1786. This is accordingly adopted.

22 *Trochulus sericeus*. As Falkner *et al.* (2002) point out, the name *plebeius* has been wrongly applied to the taxon listed above as *Trochulus sericeus* (Draparnaud). Forcart (1965) originally proposed the replacement of the name *sericeus* by the younger name *plebeius* to sort out a difficult taxonomic problem relating to the validity of the name *sericeus* (Draparnaud, 1801) in contradistinction to *sericeus* (Müller, 1774). However, in so doing, he synonymised what have subsequently been regarded as two distinct species, one widespread in north-west Europe, the other confined to the alpine region. This error has insinuated itself into most recent British and European lists and, although the taxonomic difficulties involved in the use of the name *sericeus* (Draparnaud) are not yet resolved, the eventual validation of this name for the British species seems a likely outcome.

On the other hand, Naggs (1985) has exhaustively examined morphological variation of *sericeus* (= *plebeius*) in Britain and could find no consistent or distinctive differences from the very common *Trochulus hispidus*. Prockow (2000) likewise, could find no consistent diagnostic internal or external characters separating the two in Europe. The narrowly de-limited distribution of *sericeus* in Britain does, however, argue for some characteristic which recorders can recognise in a consistent way. Naggs (pers. comm.),



has now uncovered a consistent internal difference between the two. The spermatheca (gametolytic sac) of *sericeus* is consistently spherical (as long as broad) whereas that of other British *Trochulus* is consistently longer than broad i.e. ovate. The extent of overlap appears to be very small. This distinction applies also to populations of *sericeus* from central France. *Trochulus sericeus* is retained in the current List.

23 *Zenobiella subrufescens*. Kerney (1999) placed this species in *Perforatella* following current European practice, but Falkner *et al.* (2001) subsequently elevated subgenus *Zenobiella* of *Perforatella* to generic status. So the species is once again *Zenobiella subrufescens* as in earlier British Lists (Waldén 1976, Kerney 1976b).

24 *Lehmanna nyctelia*. Quick (1960) reported this species from an indoor heated environment in Edinburgh but it has recently been found naturalised in a garden at Crediton, Devon (pers. comm. of S. M. Davies). It is difficult if not impossible to reliably distinguish from *L. valentiana* on external characters and differs mainly in the longer penis and by the lack of a flagellum. Waldén (1976) thought that its internal characters were intermediate between *Lehmanna* and *Malacolimax* and that these subgenera were poorly differentiated. However, other *Lehmanna* such as *L. szigethyae* Wiktor also lack a flagellum and there are other good characters such as folding of the internal wall of the penis, separating *Lehmanna* and *Malacolimax*. The genitalia of *L. nyctelia* are figured by Quick (1960).

25 *Limacus maculatus*. The phylogeny of this species is contentious. Forcart (1986) and Wiktor (2001) place it either in genus *Limacus* or in *Limax* subgenus *Limacus*. A contrary view is taken by Giusti (1973) and by Giusti *et al.* (1995) who place *maculatus* outwith *Limacus* and in *Limax* sensu stricto. The argument, though not heretofore expressed in such terms, is essentially about whether similar character states in *maculatus* are synapomorphic to those of *flavus* i.e. derived recently from common descent. It is certainly difficult to envisage such divergent features as egg shape, body colour, watery nature of the body mucus and integument and possession of a long caecum in the intestine, which these species share, as other than strong evidence for a close relationship i.e. synapomorphy. The peculiar placement of the spermathecal canal in *L. flavus* i.e. located in the wall of the penis rather than in the wall of the oviduct (as in *maculatus*), is often regarded as plesiomorphic i.e. indicating independent descent and a more distant relationship. However, this must be balanced against the much greater number of shared, potentially apomorphic, characters. While the penial conjunction of the spermatheca can be seen as a primitive character found otherwise only in a few Ponto-Caspian limacids, it may also be viewed as part and parcel of a more general variability in placement and size of organs within the reproductive system in *Limax* and allied genera. What then of the erection of a separate genus (*Limacus*) to accommodate *maculatus* and *flavus*? This can still be justified on the character states common to both and listed above, which also indicate that *Limacus* occupies a position intermediate between *Limax* sensu stricto and *Lehmanna*.

26 *Lymnaea fusca/palustris*. In a phylogenetic analysis of the European Lymnaeidae Barges *et al.* (2001) judged the genetic distance between species in *Stagnicola* and *Lymnaea* sensu stricto to be too small to justify separation at the generic level, thereby placing *Stagnicola* as a subgenus of *Lymnaea*, rather than as a separate genus. As yet this conclusion has not been accepted or incorporated into the Clecom List or the online Fauna Europaea List of Bank and collaborators (2004). To be consistent with the aims of the present List, as stated in the Introduction, notice is taken of this development and *fusca* and *palustris* are included under *Lymnaea* subgenus *Stagnicola*.

27 *Lymnaea fusca*. Carr & Killeen (2003) introduced this species to the British list as *Stagnicola fuscus*. It appears to be by far the commonest segregate of *Lymnaea palustris* agg. in Britain and Ireland. *Lymnaea palustris* seg., on the other hand, appears to be rare with only a small scatter of records for eastern Britain, not having been found in Ireland. Claims that a third segregate *Lymnaea corva* (Gmelin) occurs in Britain and Ireland (Falkner *et al.* 2001; Moorkens & Speight 2001) must be treated with caution as the determinations appear to have been made on conchological characters. A large sample of both British and Irish material has been dissected and only *L. palustris* and *L. fusca* verified so far. Falkner *et al.* (2001) do not record *L. fusca*, the commonest species, for the Britannic area.

28 *Radix balthica*. The complex synonymy of this species is discussed by the authors of the Clecom List (Falkner *et al.* 2001; Falkner *et al.* 2002). Historically, European authors have claimed that there are two closely allied species in northern Europe, a high-spined form identified (by them) as *Radix peregra* (Müller) and a very common low-spined form called *R. ovata* (Müller). Recent phylogenetic research (Bargues *et al.* 2001) has demonstrated, that there are indeed two closely related but distinct *Radix* in central Europe, but only one in northern Europe. The higher spined of these taxa is not the common, moderately high-spined N. European morphotype but a much rarer central or alpine species. It appears that this is absent from northern Europe including Müller's type locality for *peregra* in Denmark. The alpine taxon should be called *R. labiata* (Rossmässler). This leaves the much more widespread and common species, still with two forms (and two names), to be dealt with. The higher-spined morphotype (not as high spined as *labiata*) is traditionally called *R. peregra* (Müller) and the low-spined morphotype, *R. ovata* (Müller).

These two forms have achieved recognition partly through the misunderstanding outlined above, but mostly due to a difference in ecology. In effect, they are ecotypic. The low-spined form is common in slow or still waters and the higher-spined form in running waters. Since only one variable species is now recognised, Müller's names are synonyms. So far so good. Unfortunately, the name *ovata* is also now a synonym of an earlier Linnean name, *R. balthica* (L.) (Linnaeus designated what was subsequently perceived as a 'mixed' collection of high and low-spined forms for this name, but the acceptance of a single unifying taxon now releases the name). Therefore, three names are available.

The name *balthica* has priority over Müller's two names on date of publication and is used by Falkner *et al.* (2001, 2002). However, *peregra* (Müller) is listed as a conserved name under ICZN Opinion 336, so *balthica* should revert to the status of a synonym. Falkner *et al.* (2002) argue against this on the basis that it will clarify the identity of the northern species if it is re-named, distinguishing it from historically confused designations such as that of Hubendick (1951) which had a very broad compass and included species now considered distinct from *peregra* such as *ampla* (Hartmann) and *labiata*. This argument is accepted here.

29 *Oxychilus*, *Ortizius*. *Oxychilus alliarius* and *O. navarricus* are placed in subgenus *Ortizius* Forcart, 1957 in the Clecom List. Giusti & Manganelli (1999, 2002) argue against this ordination and place *Ortizius* in synonymy with subgenus *Oxychilus* s.s. *Ortizius* according to Giusti & Manganelli (1999, 2002) is not a natural group and members cannot be distinguished reliably from the members of subgenus *Oxychilus*. Species in subgenus *Oxychilus* possess, in common with those listed for *Ortizius*: penis with a flagellum; penial retractor inserted at the apex of the flagellum; penis ornamented internally with pleats; long epiphallus; epiphallus internally with slender longitudinal pleats; mucus gland mainly vaginal; central teeth on the radula with long mesocones. The synonymy of Giusti & Manganelli (1999) is followed here.



30 *Oxychilus navarricus helveticus*. Falkner *et al.* (2001) have postulated that *Oxychilus helveticus* is conspecific with a Pyrenean taxon, *Oxychilus navarricus* (Bouguignat, 1870). The latter name has priority on date of publication, but because these are regarded as two geographical races of the species, the northern one, originating from the alpine region and widespread in the British Isles, they called *navarricus helveticus* (Blum). The validity of this hypothesis has not been adequately tested and there is no way of knowing if phylogenetic analysis will produce the same result. This creates a dilemma, because in the present List I have specifically resisted recognising subspecies without phylogenetic evidence, as the concept has traditionally been so disordered in application. I make an exception here because there is so little contrary evidence to go on, and accept the Clecom analysis for the time being.

31 *Physella, Haitia*. Taylor (1988, 2003) has transferred *Physella acuta* to the genus *Haitia* Clench & Aguayo, this being the earliest available name (other than *Costatella* Dall), in a revision which involved, among other things, elevating former subgenera to genera. *Haitia* (which Taylor used in an earlier paper, Taylor (1988)) was validated by him following the erection of a separate genus for the type species of *Costatella*, *costata* Newcomb, which took *Costatella* out of contention as the earliest valid name for the *acuta* clade. These changes rest upon a raft of assumptions about the validity of the new taxonomic units which are difficult to test without relevant phylogenetic or breeding studies.

However, Remigio *et al.* (2001), in an examination of the evolutionary origins of *Physella* (*Physella*) *gyrina* and of two localised spring species *Physella* (*Physella*) *wrighti* Te & Clarke and *Physella* (*Costatella*) *johnsoni* (Clench), have come to interesting conclusions about the ordination of N. American Physidae. They concluded that *wrighti* is the ancestral form from which *gyrina* and *johnsoni* arose 10,000 years ago, after the last major glaciation. DNA analysis established that *gyrina* and *johnsoni* are very closely related (0.0 to 0.4% distance at 16S ribosomal RNA) despite being classified in different subgenera i.e. in *Physella* and *Costatella* respectively. They are in fact about as related as *gyrina* and *wrighti* to each other even though the latter are in the same nominal clade. The authors conclude that genetic distance, calculated from the DNA analysis, is insufficient to justify subgeneric partition for these species. This does not sit well with the revision being proposed by Taylor (2003). In the circumstances it seems wiser to retain *Physella* for both the *gyrina* and *acuta* clades until some of the issues raised by these findings can be further investigated. As an aside, comparison of a species of *Physa* with the above *Physella* species by Remigio *et al.* (2001) indicated a much more ancient divergence, justifying the widely accepted generic separation of *Physa* from *Physella*.

32 *Physella acuta*. The taxonomic status of the putative British species *Physella acuta* and *Physella heterostropha* are discussed by Anderson (2003). *Physella heterostropha* is reduced to synonymy with *P. acuta* on the basis both of morphological homogeneity (Anderson 2003) and lack of breeding isolation in experiments conducted on N. American samples of the morphotypes (Dillon *et al.* 2002).

33 *Anisus leucostoma/spirorbis*. Falkner *et al.* (2001) list two species of *Anisus* subgenus *Anisus* for the British Isles i.e. *spirorbis* (L.) and *leucostoma* (Millet) representing broad-whorled and narrow-whorled morphotypes respectively. They have also replaced the name *leucostoma* with *septemgyratus* (Rossmässler). The latter change is not followed by Glöer (2002).

The separation of *Anisus spirorbis* from *A. leucostoma* continues to be problematical. Glöer (2002) remarks that a population studied by Wawrczinek at St Georges-du-Bois varied in conchological characters, and therefore species assignment, between years



and that some specimens possessed internal characters intermediate between the two putative taxa. Reliable evidence of specific distinction for the broad-whorled form *spirorbis* is therefore in my view still not available. This issue will undoubtedly be examined phylogenetically at some future point, but in the meantime two species are retained (nomenclature of Glöer (2002)).

34 *Ferrissia wautieri*. The name to be applied to this taxon is contentious. In the Clecom List it is considered synonymous with *F. clessiniana* (Jickeli, 1882), which was described from Alexandria in Egypt. Falkner *et al.* (2002) regard it as distinct from related N. American species as well as native to Europe. Glöer (2002) retains the name *F. wautieri* on the basis that its identity and internal morphology are well established whereas some of the alternative contenders are poorly characterised. Glöer (2002) is followed here.

*Ferrissia* was first recorded in Britain from a pond at Bishop's Waltham in Hampshire and from indoor aquaria (Brown 1977) the latter occurrence suggesting a potential mechanism for its introduction and spread. A North American origin seems likely, notwithstanding the contentions of Falkner *et al.* (2001, 2002), and the relationship with species in the N. American fauna needs to be more fully explored.

35 *Paralaoma servilis*. The present species has had a long and complex taxonomic history which Falkner *et al.* (2002) have ingeniously disentangled. The correct name for the small shell called *Paralaoma caputspinulae* by Kerney (1999) is *P. servilis*.

36 *Pupilla bigranata*. *Pupilla bigranata* is listed for Britain by Falkner *et al.* (2001). Barry Colville (pers. comm.) has commented on British populations containing individuals with *bigranata*-like shells. Where specimens with *bigranata*-like shells are present, normal *muscorum* also occur and specimens with characters intermediate between the typical forms are invariably present also. Communities with *bigranata*-like individuals appear scarce in Britain and have not been recorded in Ireland. This name is omitted from the List for lack of evidence of the occurrence of a distinct biological species.

37 *Pyramidula pusilla*. *Pyramidula rupestris* s. l. comprises a range of morphotypes in Europe. The review of Gittenberger & Bank (1996) has reversed an early (19th century) lumping of taxa in European *Pyramidula* and recognises several species and subspecies. The common European species under this scheme is *P. pusilla* (= *rupestris* auct. non Draparnaud, 1801) of which the British and Irish form has been designated subspecies *umbilicata* (Montagu). The Clecom List (Falkner *et al.* 2001) has taken this a stage further by elevating *umbilicata* to species rank. As yet, apart from controversial conclusions based on shell morphology in the original review, little justification has been provided for the latter change. A middle view is taken here with the British species aligned with the common north-west European form *pusilla* (Vallot) until further evidence is available.

38 *Oxyloma elegans/sarsi*. There has been a consistent difference in usage of the name *elegans* between British and Scandinavian authors on the one hand (Waldén 1976), and most Continental authors on the other. The latter have used this name for the most widespread of the European species of *Oxyloma* and the former for a different, much rarer, northern taxon. Falkner *et al.* (2002) have re-examined the types of *elegans* in MHNM and compared these with topotypes from Risso's locus typicus in the Camargue. This study has confirmed earlier European studies which identified Risso's *elegans* as the common European species. Accordingly, the name *pfeifferi* of British authors becomes a junior synonym of *elegans*, and *sarsi* is applied to the northern taxon previously called *elegans* by British and Scandinavian authors.

39 *Vallonia* cf. *excentrica*. A recent phylogenetic analysis by Korte & Armbruster (2003) indicates that *V. excentrica* comprises two paraphyletic taxa which are difficult or impossible to distinguish on shell morphology. The situation is therefore similar to that applying to *Cochlicopa lubricella* (see Note 15). As it is impossible to identify which of the paraphyletic taxa occur in Britain and Ireland, the *excentrica* complex is indicated in the list as *Vallonia* cf. *excentrica* pending further investigations.

In addition Korte & Armbruster (2003) found that *Vallonia pulchella* is closely allied to, and may be synonymous with, *Vallonia enniensis*. However, this does not affect use of the name *pulchella* for British material.

40 *Truncatellina cylindrica*. This species is included by Ross (1984) in an Irish List but inclusion rests upon a single shell collected by William Thompson at Groomsport, Co. Down in the mid 19th-century and discovered recently in Thompson's collection. As it is difficult to be sure of the age of the Groomsport specimen, and the site appears to have been unsuitable for this species during the modern era, a decision has been taken to remove it from the Irish part of the present List. Although subfossil shells are present in Quaternary dune deposits in north Antrim/Londonderry (Welch 1898) there is no indication that the species survived in Ireland into modern times.

41 **Sphaeriidae subgenera.** Killeen *et al.* (2004) are followed here, in that subgenera and subspecies are not recognised in the Sphaeriidae.

42 *Sphaerium nucleus*. Added to the List by Killeen *et al.* (2004) and so far known from three areas of grazing marsh in south-east England. It is since reported from two sites on the Royal Canal, Co. Longford, Ireland (Moorkens 2005). The Clecom List records *Sphaerium ovale* (Férussac, 1807) for Britain and Ireland but Killeen *et al.* (2004) note that there are no authenticated field records and that further work is needed to confirm its occurrence. It is excluded from the present list.

43 *Radix rubiginosa*. This small lymnaeid has been observed on several occasions in tropical aquaria in Ireland and there is a colony in the Victoria House at Kew Gardens, Richmond, Surrey (R. Anderson, unpublished observations). It is distinguished from related tropical lymnaeids by the heavily pigmented and spotted praeputium, by the strong development of the dual bundles of musculature inside the praeputium, by the way in which these taper proximally in the sarcobelum, and by the long (equal or subequal in length to the praeputium) and slender, penis and penis sheath (Hubendick 1951). The prostate has a single fold. The shell is similar in shape to another widespread Asiatic species *R. luteola* (Lamarck), but the sutures are much deeper and the shell is pale to deep horn colour, lacking the brown apex and striping often seen in *luteola*. *Radix rubiginosa* has been reported from heated aquaria in Israel (Mienis 1986). Its native range is Indo-China and Indonesia (Hubendick 1951) where it can be an important vector for helminthic parasites.

44 *Gyraulus chinensis*. *Gyraulus chinensis* is native to east Asia and is another common species of tropical aquaria (R. Anderson unpublished; McMillan 1998). It is naturalised in west and south Africa (Appleton 1996) and in rice fields of southern Spain, from whence it is distributed sporadically northwards, mainly in artificially heated environments, to Germany (Brown *et al.* 1999).

45 *Planorbella duryi*. This is the common ramshorn found in the tropical aquarium trade (R. Anderson unpublished). Fairly ubiquitous in aquaria and occasionally in greenhouses. There has been some confusion about the name to be applied but Horsak *et*

*al* (2004) conclude that in Austria and the Czech Republic at least, the aquarium species is *P. duryi*. Material collected from aquaria in Northern Ireland has been dissected and also corresponds to *P. duryi*. The occurrence of other species, notably *Planorbella trivolvis* (Say, 1817), cannot be ruled out.

46 *Rumina cf. decollata*. Reported in this journal (p. 714) from Caerphilly Garden Centre, South Wales, new to the British Isles

47 *Striosubulina* sp. Schileyko (1999) has revised the status of this species (formerly in *Subulina*) making it the type of a segregate genus *Striosubulina*. His justification is based upon a re-description of '*Subulina striatella*' using material collected in Kew Gardens. It has been noted (pers. comm. of F. Naggs) that Rang's original description of *S. striatella* (Rang 1831) contains a colour figure showing a dark animal. The Kew species has a pale yellow body. Some doubt therefore pertains to the name to be applied here!

## DISCUSSION

The List presented here is intended to provide a way forward for the recording community within the Conchological Society at a time of unprecedented change in the taxonomy and nomenclature of molluscs.

One objective has been to ascertain the number of taxa currently recorded from Britain and Ireland and to assign names on the best evidence available. For a number of taxa this has been a particularly difficult task because of competing opinions and the complexity of the issues involved. Decisions have been made, as far as possible, using phylogenetic criteria where research evidence is available. Historically, a great many decisions have been based largely or entirely on conchological criteria which is unwise, as in many groups conchological characters are governed by environmental as well as genetic factors. There are several examples in the List for which phylogenetic analysis would be desirable to resolve long-standing difficulties of interpretation. Use of the structure of soft parts including the male genitalia can also be misinterpreted in deciding relatedness. An example has been cited in Note 8, dealing with British *Physella* spp. Overall, a balance has been sought between external and internal morphology, though in the end giving precedence to molecular studies.

This List, as with all lists, is not the last word on the subject and will undoubtedly require to be modified as further research evidence becomes available on the outstanding issues.

## ACKNOWLEDGEMENTS

My sincere thanks are due to many people with whom I have discussed the problems inherent in the present nomenclatural revision. These include the late Dr. D. S. Brown, Dr. R. Cameron, Mr. R. Carr, Dr. B. Colville, Ms S. M. Davies, Prof. Folco Giusti, Mrs. G. A. Holyoak, Dr. D. Holyoak, Mr. I. Killeen, Mr. F. Naggs, Dr. E. Moorkens, Dr. R. C. Preece. I am particularly indebted to Geraldine Holyoak whose scientific curiosity, enthusiasm and support have been invaluable in the researches leading to the production of this report.



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# NEW DATA ON THE SYSTEMATICS AND DISTRIBUTION OF THE OXYCHILINE ZONITID *MEDITERRANEA DEPRESSA* (STERKI, 1880) IN ITALY (GASTROPODA: PULMONATA: ZONITIDAE)

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*Abstract* Recent extensive field research has made it possible to improve definition of the distribution of *Mediterranea depressa* in northern Italy. The species only occurs in the Alps: from Laghi di Fusine to Cadore in the eastern Alps and in two isolated localities in the western Alps. Apart from the apparent absence of thorns at tip of mid-penis papillae, Italian specimens have all the conchological and anatomical characters of the species.

The genus *Riedeliconcha* established by Schileyko (2003) to include this species is here regarded as a junior synonym of *Mediterranea*. In fact the type species of these genera share subterranean life-style, small whitish shell with very small umbilicus and many anatomical characters.

*Key words* *Mediterranea depressa*, *Oxychilus*, *Riedeliconcha* distribution, taxonomy, systematics, Italy.

## INTRODUCTION

Among the many oxychiline zonitids formerly assigned to the genus *Oxychilus*, occurring in northern Italy, *Mediterranea depressa* (Sterki, 1880), is one of the lesser known. Reported for many European countries (from E-France to Switzerland, Liechtenstein, S-Germany, Austria, Hungary, Czech Republic, Slovakia, Poland, Slovenia, Albania, Montenegro, N-Greece, Bulgaria and Romania; Grossu, 1983; Kerney *et al.*, 1983; Dhora & Welter-Schultes, 1996; Bole & Slapnik, 1997; Riedel, 1998; Falkner *et al.*, 2001) and defined as a "Karpatisch-alpine Art" by Riedel (1980), the species was, in fact, only known from the upper Piave Valley where it was first recorded by Ehrmann (1933) and then by Schrott & Kofler (1973). Since the upper Piave Valley divides two major mountain groups: the Dolomites to the west and the Carnic Alps to the east, the species has been reported in Italy as widespread in the Carnic Alps (Boato *et al.*, 1989; Manganelli *et al.*, 1995), or in the Dolomites and the Carnic Alps (Alzona, 1971).

We have recently done extensive field research in the eastern Alps, collecting much new material on the species, which has made it possible to better define its distribution in northern Italy.

## MATERIAL AND METHODS

Whole shells were photographed under the light microscope (Wild M5A). All dimensions (NW number of whorls, SD shell diameter, SH shell height, UD umbilicus diameter) were measured using a micrometer.

Live specimens were drowned in water, then fixed and preserved in 75% ethanol buffered with NaHCO<sub>3</sub>. The bodies were isolated after crushing the shells and dissected under the light microscope (Wild M5A) using thin pointed watchmaker's tweezers. Anatomical details were drawn using a Wild camera lucida.

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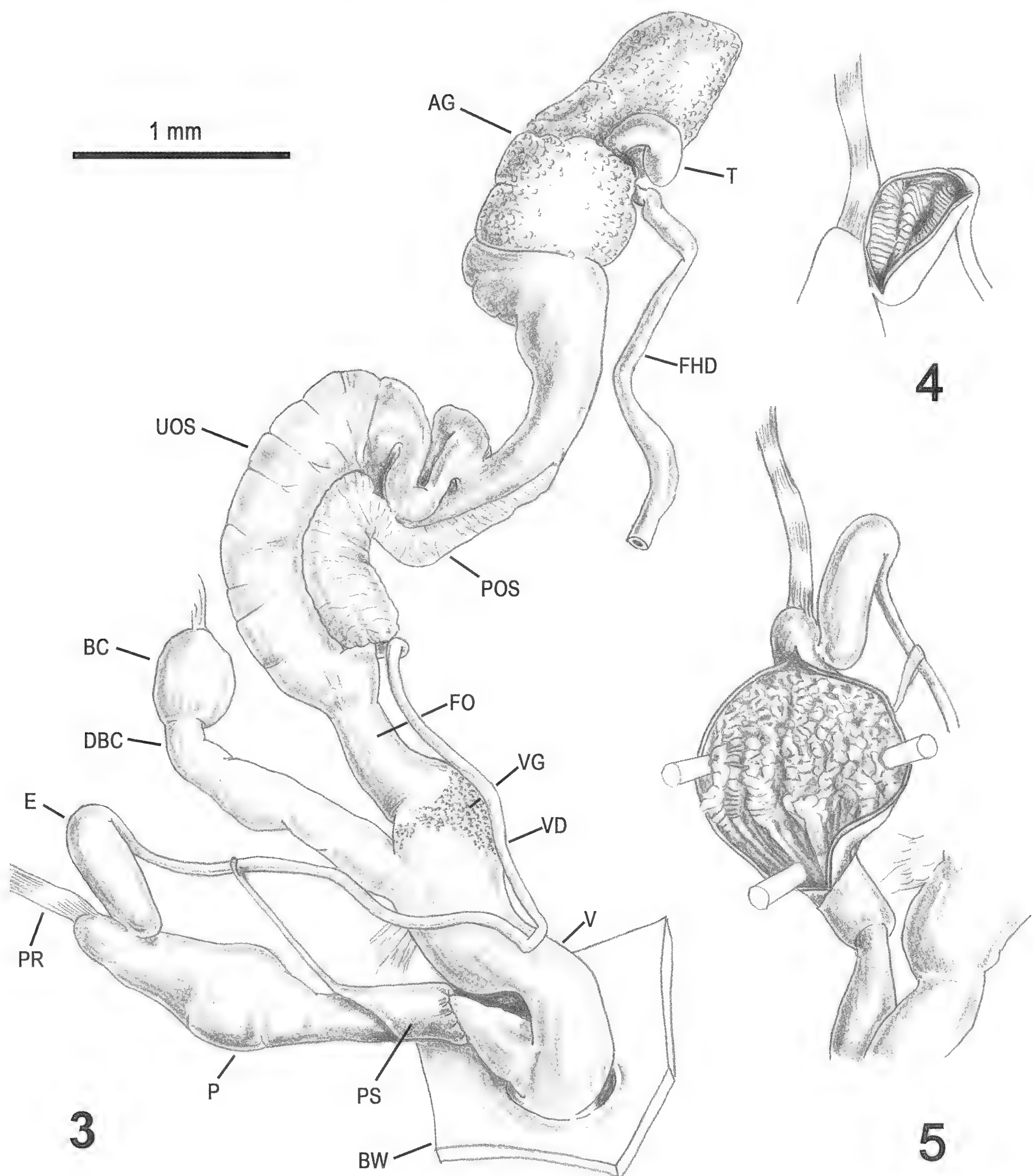


**Figs 1-2** Two shells of *Mediterranea depressa* (Sterki, 1880) from Lago Sauris, 870m (Sauris, Udine), 33TUM24, S. Cianfanelli leg. 17.04.1995 (Fig. 1) and Vallon Rio delle Miniera, 1975m (Sappada, Belluno), 33TUM2462, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 23.08.2002 (Fig. 2).

The material examined is listed as follows: locality, UTM reference, collector(s), date, number of specimens in parenthesis. Locality names and UTM references are according to the sheets of the 1:25,000 scale map of Italy (Series M 891).

Key to museum and collection acronyms: SCC S. Cianfanelli collection, Firenze, Italy, MBC M. Bodon collection, Genova, Italy, INC I. Niero collection, Spinea, Italy.

Key to acronyms used in Fig. 3: AG albumen gland, BC bursa copulatrix, BW body wall, DBC duct of bursa copulatrix, E epiphallus, FHD first hermaphrodite duct, FO free oviduct, P penis, POS prostatic portion of ovispermiduct, PR penial retractor, PS penial sheath, T talon, UOS uterine portion of ovispermiduct, V vagina, VD vas deferens, VG vaginal gland.



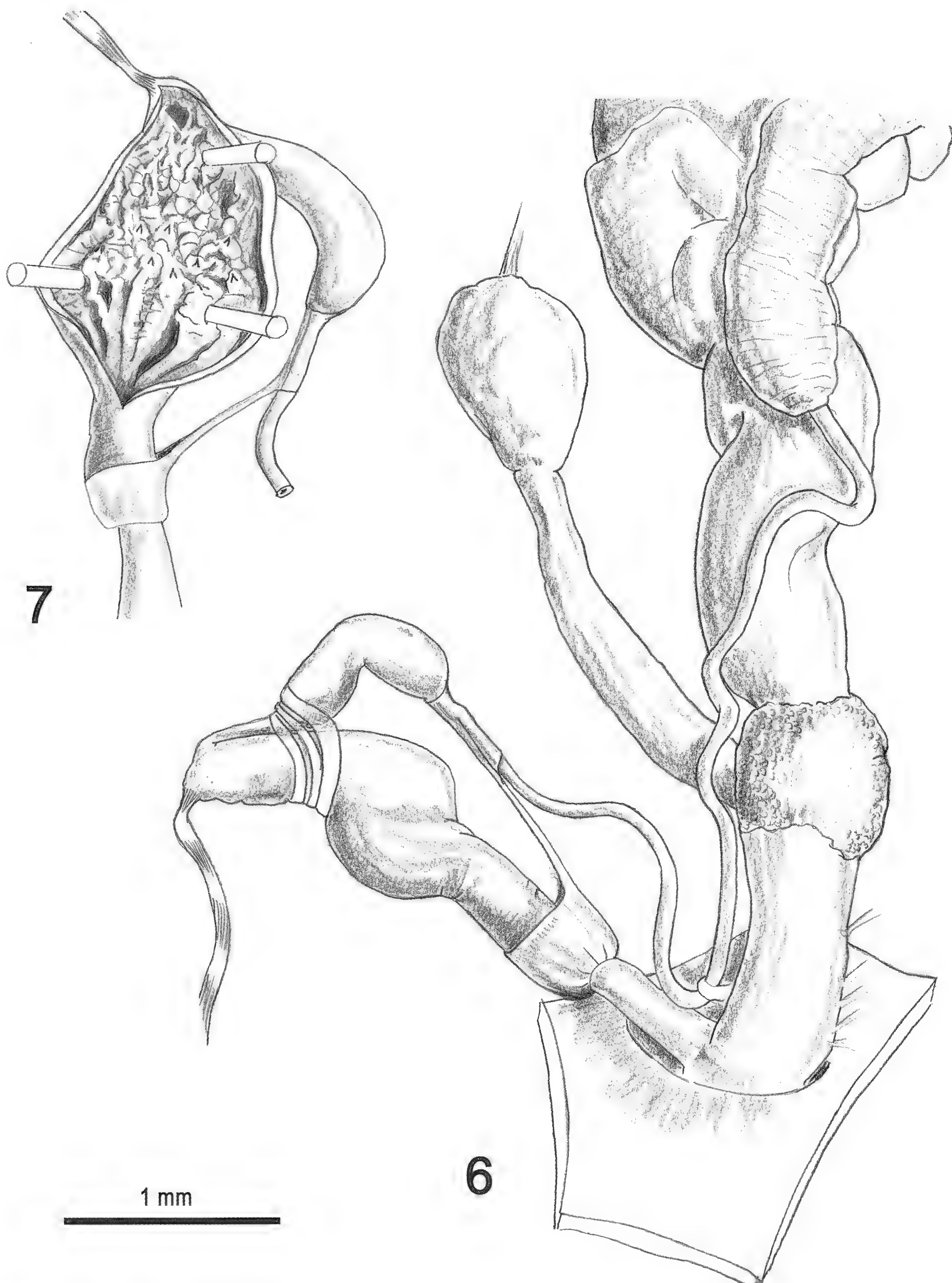
**Figs 3-5** Distal genitalia (Fig. 3), internal ornamentation of proximal penis (Fig. 5) and of epiphallus (Fig. 4) in a specimen of *Mediterranea depressa* (Sterki, 1880) from Valle di Sesis, near Rifugio Piani di Cristo, 1430 m (Sappada, Belluno), 33TUM2661, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 21.08.2002.

## RESULTS AND DISCUSSION

*Material examined* **LR36** South-eastern slope of Testa del Chargeur, 2025 m (La Thuile, Aosta), 32TLR3763, M. Bodon leg. 15.07.1997 (1 sh MBC).

**MR26** Miniera Argentera Superiore, 1540 m (Mosso Santa Maria, Biella), 32TMR2460, T. Pasiutto & R. Palestro leg. 05.07.1998 (1 sh MBC).

**TM95** Val d'Oten, Capanna degli Alpini, 1500 m (Calalzo di Cadore, Belluno),



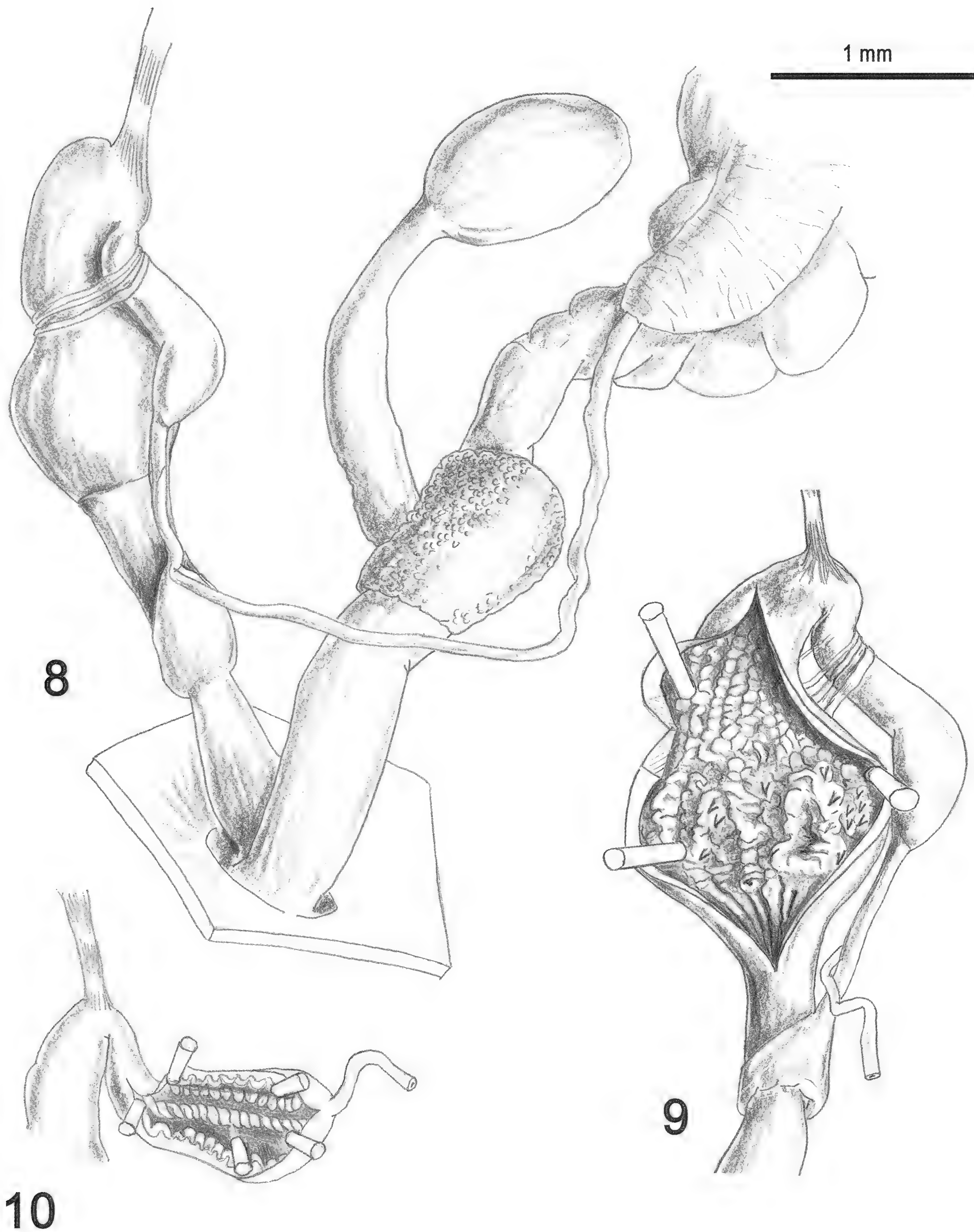
**Figs 6-7** Distal genitalia (Fig. 6) and internal ornamentation of proximal penis (Fig. 7) in a specimen of *Mediterranea depressa* (Sterki, 1880) from Gruszowiec near Mszana Dolna (West Carpathians), A. Riedel leg. 08.10.1975.

33TTM9151, I. Niero leg. 16.09.2003 (2 sh INC).

**UM04** Val Cimoliana, near Rifugio Pordenone, 1250 m (Cimolais, Pordenone), 33TUM0740, I. Niero leg. 23.08.1985 (2 sh INC).

**UM15** Northern slope of Monte Col, 1150 m (Santo Stefano di Cadore, Belluno),





**Figs 8-10** Distal genitalia (Fig. 8), internal ornamentation of proximal penis (Fig. 9) and of epiphallus (Fig. 10) in a specimen of *Mediterranea depressa* (Sterki, 1880) from Zwierzyniec (Zamasc), A. Riedel leg. 26.05.1955.

33TUM1358, I. Niero leg. 01.09.2003 (1 sp, 2 sh INC).

**UM24** Lago Sauris, 870 m (Sauris, Udine), 33TUM24, S. Cianfanelli leg. 17.04.1995 (1 sh SCC 6151/1012). Rifugio Piaz, 1120 m (Ampezzo, Udine), 33TUM24, S. Cianfanelli leg. 05.04.1999 (4 sh SCC 9025/2016). Rifugio di Monte Pura, 1400 m (Ampezzo, Udine), 33TUM2643, S. Cianfanelli leg. 06.08.1999 (1 sh SCC 9026/2080).

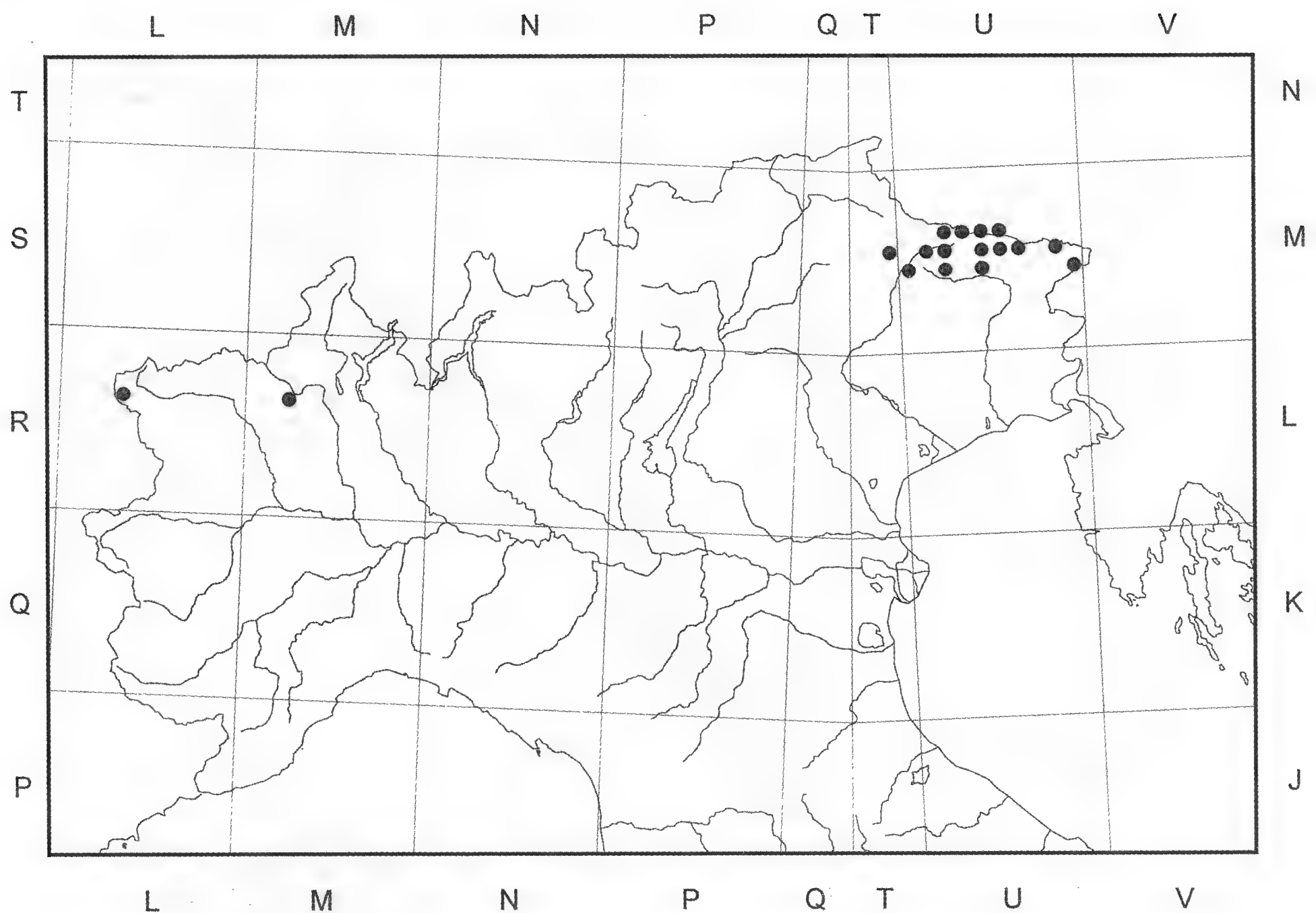


Fig. 11 The geographic distribution of *Mediterranea depressa* (Sterki, 1880) in Italy (points correspond to 10 x 10 km squares of UTM grid).

**UM25** Northern slope of Monte Siera, 1350 m (Sappada, Belluno), 33TUM2559, I. Niero leg. 16.09.2000 (1 sh INC).

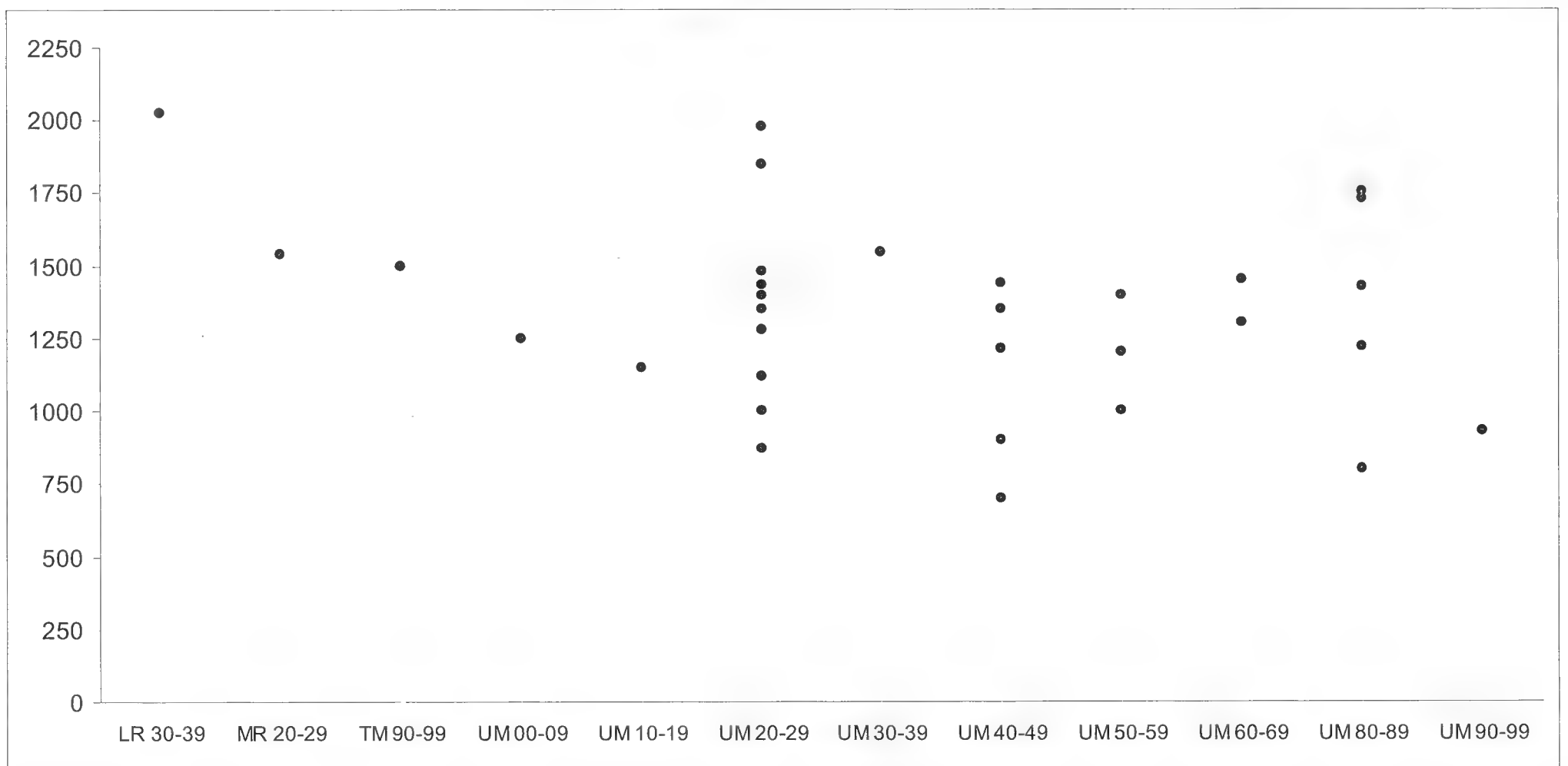
**UM26** Vallone Rio della Miniera, 1480 m (Sappada, Belluno), 33TUM2562, I. Niero leg. 22.07.2003 (1 sh INC). Vallone Rio della Miniera, 1975 m (Sappada, Belluno), 33TUM2462, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 23.08.2002 (8 sh SCC 14571/3292). Monte Chiandenis, 1850 m (Sappada, Belluno), 33TUM2565, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 21.08.2002 (15 sh SCC 14568/3282). Valle di Sesis, near Rifugio Piani di Cristo, 1430 m (Sappada, Belluno), 33TUM2661, M. Bodon leg. 17.07.1993 (108 sh MBC; 3 sh SCC 4080/681); S. Cianfanelli leg. 14.08.1999 (1 sp, 4 sh SCC 9024/2106); S. Cianfanelli leg. 21.04.2000 (5 sh SCC 18781/2191); M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 21.08.2002 (1 sp, 2 sh SCC 14569/3286). Stretta del Fleon, 1000-1400 m (Forni Avoltri, Udine), 33TUM26, S. Cianfanelli leg. 24.08.1997 (1 sh SCC 9401/1600). Stretta del Fleon, 1280 m (Forni Avoltri, Udine), 33TUM2966, I. Niero leg. 16.06.1999 (2 sh INC).

**UM36** Collina Pian di Val di Bos, 1547 m (Forni Avoltri, Udine), 33TUM3762, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 23.08.1999 (23 sh SCC 9020/2123).

**UM44** Northern and northeastern slope of Monte Strabut, 700-900 m (Tolmezzo, Udine), 33TUM4942, S. Cianfanelli leg. 11.08.2001 (49 sh SCC 18798/2700); 17.08.2002 (46 sh SCC 14560/3275).

**UM45** Casera Meledis, 1215 m (Paularo, Udine), 33TUM4157, S. Cianfanelli leg. 21.07.2000 (1 sh SCC 18793/4270).

**UM46** Passo Monte Croce Carnico, 1350-1440 m (Paluzza, Udine), 33TUM4263, S. Cianfanelli leg. 29.08.1999 (20 sh SCC 2218/2151); 22.07.2000 (12 sh SCC 18794/4275); M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 28.08.1999 (8 sh SCC



**Fig. 12** The altitudinal distribution of *Mediterranea depressa* (Sterki, 1880) in Italy in relationships to a longitudinal gradient (for detail on the localities, see material examined; in the case of collections made at different altitude, minimum and maximum extremes were considered).

9022/2150).

**UM55** Casera Valbertad bassa, 1400 m (Paularo, Udine), 33TUM5859, S. Cianfanelli leg. 21.08.1999 (2 sh SCC 9021/2118).

**UM56** Casera Ramaz, 1000-1200 m (Paularo, Udine), 33TUM56, S. Cianfanelli leg. 08.08.1988 (2 sh SCC 8341/973). Casera Meledis bassa, 1215 m (Paularo, Udine), 33TUM5760, S. Cianfanelli leg. 16.08.1999 (3 sh SCC 9023/2109).

**UM65** Valle Rio Bombaso, 1300-1450 m (Pontebba, Udine), 33TUM6856, S. Cianfanelli leg. 25.04.2000 (8 sh SCC 18785/2209); 25.04.2000 (3 sh SCC 18786/2210); M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 14.08.2000 (1 sh SCC 18796/2375).

**UM85** Monte Stabet, 800 m (Tarvisio, Udine), 33TUM8052, S. Cianfanelli leg. 14.09.1990 (1 sh SCC 1801/99). Rifugio Nordio, 1220 m (Malborghetto Valbruna, Udine), 33TUM8356, S. Cianfanelli leg. 14.09.1990 (1 sh SCC 1916/106). Sella di Lom, 1425 m (Malborghetto Valbruna, Udine), 33TUM8357, S. Cianfanelli leg. 27.08.2001 (1 sh SCC 18812/2762). Madonna delle Nevi, 1750 m (Malborghetto Valbruna, Udine), 33TUM8557, S. Cianfanelli leg. 27.08.2001 (3 sh SCC 18808/2753). Sella Bistrizza, 1730 m (Malborghetto Valbruna, Udine), 33TUM8557, S. Cianfanelli leg. 27.08.2001 (1 sh SCC 18810/2756).

**UM94** Lago di Fusine superiore, 930 m (Tarvisio, Udine), 33TUM94, M. Calcagno, S. Cianfanelli, G. Manganelli & L. Manganelli leg. 25.08.1999 (1 sh SCC 9019/2138).

**Systematics** Unable to find any synapomorphy supporting monophyly, two of us (Giusti & Manganelli, 1999) concluded that the genus *Oxychilus* Fitzinger, 1833, as then conceived, was not a natural taxon and stressed the need for a new approach to its systematics. Natural groups identified by sets of anatomical characters, some probable synapomorphies, admittedly existed in *Oxychilus* s.l. and we identified *Mediterranea* Clessin, 1880 (type species: *Helix hydatina* Rossmässler, 1837), as one of these. However, because the rank of these groups had to be ascertained, we preferred to continue using the current taxonomy and nomenclature, considering them subgenera pending careful revision of all the single groups and phylogenetic analysis of the entire ensemble. Falkner *et al.* (2001, 2002) subsequently took our ideas to its extreme consequences, adopting a new systematics for *Oxychilus*: they saved some of the traditional subgenera



(*Oxychilus* s.str., *Ortizius* Forcart, 1957, etc.), but raised others to the rank of distinct genera (*Cellariopsis* Wagner, 1915, *Morlina* Wagner, 1914, *Mediterranea*, etc.).

Falkner *et al.* (2001, 2002) did not motivate their action and have *de facto* undermined the unity of the genus *Oxychilus*. It is now inopportune, if not impossible, to continue to use the traditional systematics, at least in the cases, such as that of *Mediterranea*, in which distinction at genus level has more evident support.

Until recently, *Hyalina depressa* was assigned to the subgenus *Riedelius* Hudec, 1961 (type species *Hyalina inopinata* Uličný, 1887), but Giusti *et al.* (1985) demonstrated that this taxon was a junior synonym of *Mediterranea* since *H. inopinata* was a “local form” of, or “a species very related” to, *H. hydatina*. Riedel (1990) subsequently suggested conserving *Riedelius*, designating *H. depressa* as its type species, but as he did not submit any application to the ICZN on the subject, Schileyko (2003) introduced the new genus *Riedeliconcha* for *H. depressa*.

*H. depressa* and *H. hydatina* not only share a subterranean life-style and a small whitish shell with a very small umbilicus, but also many important anatomical characters (absent or very short flagellum; penial retractor inserted where epiphallus ends and proximal penis begins; internal ornamentation of penis consisting of pleats and rows of papillae, some or all with apical thorn; short epiphallus with internal series of transverse crests on one side and a few slender longitudinal pleats on the other; mucous gland forming muff of glandular tissue, denser and yellower around distal portion of free oviduct; and short mesocone on central tooth). It is therefore impossible to assign these two species to different genera – *H. depressa* to *Riedeliconcha*; *H. hydatina* to *Oxychilus* (*Mediterranea*) – as Schileyko did. In fact, in our opinion *Riedeliconcha* is a junior synonym of *Mediterranea*.

**Taxonomy** The Italian specimens *Mediterranea depressa* examined match all conchological (Figs 1-2) and anatomical (Figs 3-5) characters of the species (for the shell, see Ehrmann, 1933: Pl. 4 fig. 48; Falkner, 1990: Fig. 2 at p. 3; Turner *et al.*, 1998: Fig. at p. 280; for the anatomy, see Figs 6-10 and Riedel, 1957: Figs 29-31; 1969: Figs 11-12, 16-19; 1980: Figs 246-248; Negrea, 1975: Fig. 9). The only difference is the apparent absence of thorns at tip of mid-penis papillae, usually evident in the other specimens from eastern Europe (Figs 3-7) and frequently reported for the species (Riedel, 1969: Figs 11-12; 1980: Figs 246-248). However, no importance was attributed to this detail since the only Italian specimen examined by us was not fully adult.

**Geographic distribution** *Mediterranea depressa* has a wide distribution in central and eastern Europe (Kerney *et al.*, 1983; Dhora & Welter-Schultes, 1996; Riedel, 1998). In Italy, it occurs in the Alps: from Laghi di Fusine to Cadore in the eastern Alps and in two isolated localities of the western Alps. At present, we do not know if its rarity in the western Alps and its absence from the central Alps are real or due to insufficient field research.

**Ecology** The species is at least prevalently subterranean. It was found under large stones, partially buried or under layers of crushed limestones from the montane to the alpine belt (mean altitude  $1330.5 \pm 325.5$  m; range 700 – 2025 m).

**Status and conservation** Although it is not difficult to collect many shells in certain sites, live specimens are rare (at present only three have been collected). It is unclear whether this is due to low population density or to the fact that the species inhabits deep soil horizons.

## ACKNOWLEDGMENTS

We thank Saulo Bambi for technical assistance, Helen Ampt for revising the English, Marco Bodon (Genova, Italy) and Ivano Niero (Spinea, Italy), for information about material from their respective collections.

Research financed by MURST (grant no. 9905317452 "*Aspetti descrittivi e metodologici della biodiversità animale in Italia*") and Museo Zoologico de "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze (Italy).

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# BABYLONIA AND ZEMIOPSIS (GASTROPODA: CAENOGASTROPODA: BABYLONIIDAE), ANATOMY, SHELL MORPHOLOGY, DISTRIBUTION AND DNA

EDMUND GITTENBERGER<sup>1, 2</sup> & DENNIS R. UIT DE WEERD<sup>1, 2</sup>

*Abstract* On the basis of shell morphology, geographical distribution, and new molecular data, *Babylonia* and *Zemiopsis* are once again considered separate genera.

*Key words* Gastropoda, Caenogastropoda, Babyloniidae, systematics, COI, Indo-Pacific, E Africa

## INTRODUCTION

The nominal genus *Zemiopsis* was introduced equivalent in rank next to *Babylonia* Schlüter, 1838, by Thiele (1929: 332) on the basis of shell characters. The generic status was accepted by Altena & Gittenberger (1981: 8, 26) based on the same conchological characters and additionally, though with some doubts because of a potentially conflicting observation by Adams (1864), i.e. the presence versus absence of a medial pedal tentacle in these snails. Harasewych & Kantor (2002) observed such a tentacle in live specimens of both *Babylonia* and *Zemiopsis* species, and more generally concluded that these species do not differ anatomically. Consequently, these authors synonymized both taxa. This in turn was not accepted by Gittenberger & Goud (2003), once more referring to the conchological differences and emphasizing that the two taxa are allopatric and separated by a geographical gap of over 2500 km coast-line. To escape from the impasse, a molecular marker was isolated from some *Babylonia* and a *Zemiopsis* species, to be sequenced and analysed in order to establish the phylogenetic relationships between the various species. The four *Babylonia* species that could be used this way cover the conchological variation within *Babylonia* quite well. *Babylonia japonica* with four rows of dark blotches, a slender spire and no sutural canal, *B. spirata* with a similar colour pattern but a very prominent sutural canal, *B. areolata* with an aberrant pattern of three rows of large, squarish blotches on the shouldered body whorl, and *B. formosae habei* with shouldered whorls but without a regular colour pattern, are more or less extreme within the genus. Liu & Chiu (1998) consider *B. habei* a separate species.

## MATERIAL AND METHODS

The material used in this study is in the collections of the National Museum of Natural History, Leiden (= RMNH) and the National Museum of Natural History, Smithsonian Institution, Washington D.C. (= USNM). From the RMNH molluscan collection samples of three *Babylonia* species, kept for up to 33 years in alcohol 70%, and a relatively fresh sample of a *Zemiopsis* species were used for DNA isolation. New sequences were submitted to GenBank (for accession numbers, see below). Molecular data on a fourth *Babylonia* species, viz. *Babylonia japonica*, are from GenBank (accession number AF373888).

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TABLE 1  
Collection data

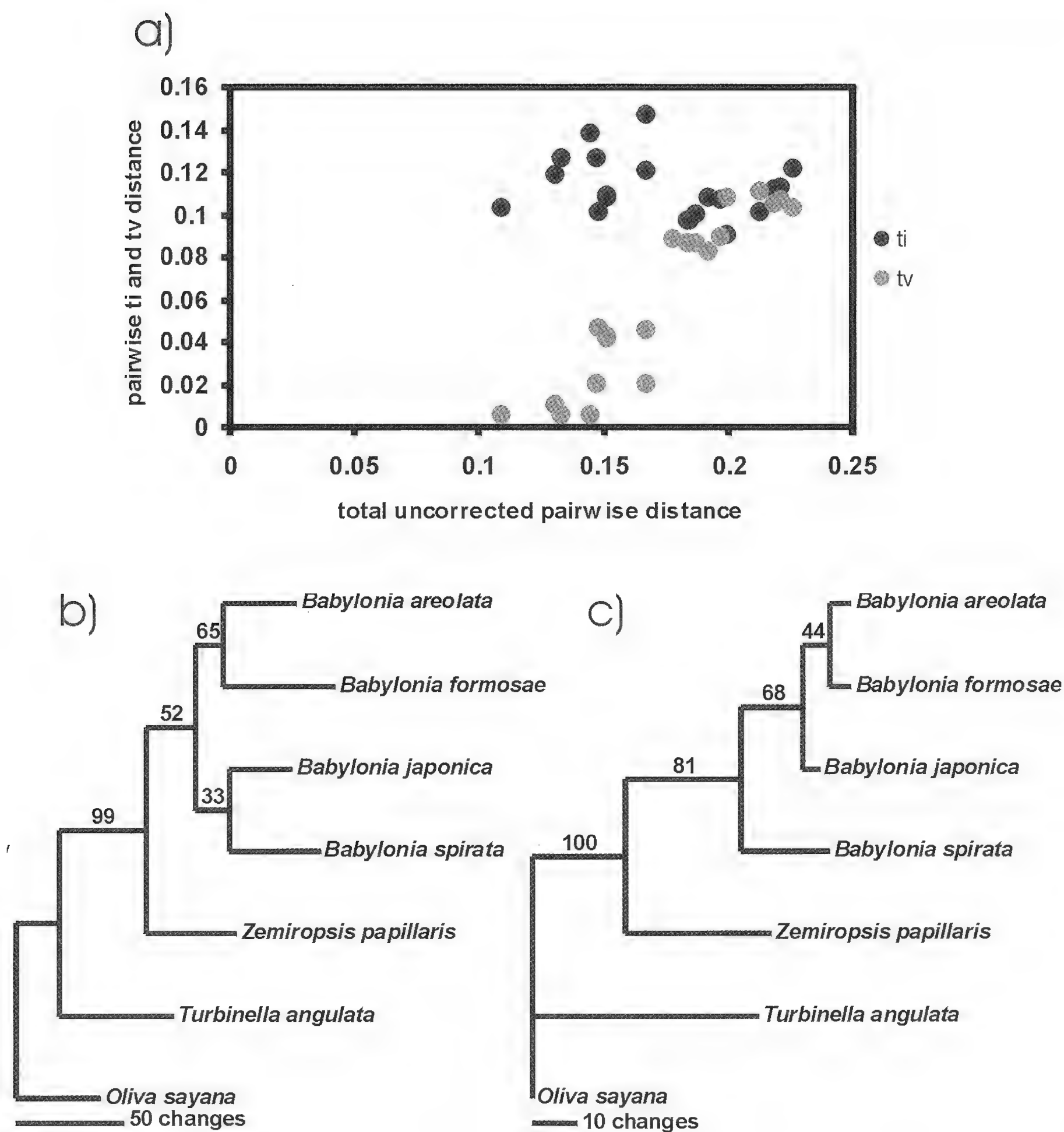
<i>Babylonia habei</i> Altena & Gittenberger, 1981	'Formosa'	T.C. Lan leg., 1971	RMNH 9009
<i>Babylonia areolata</i> (Link, 1807)	'Formosa'	T.C. Lan leg., 1971	RMNH 9015
<i>Babylonia japonica</i> (Reeve, 1842)	Osaka, Japan		USNM 894808
<i>Babylonia spirata</i> (L., 1758)	Karachi	Mozammil Ahmed leg., 1972	RMNH 9014
<i>Zemiropsis papillaris</i> (Sowerby [I], 1825)	S. Africa	B. Hayes don., 2004	RMNH 9982

Total DNA of *Babylonia areolata*, *Babylonia formosa*, *Babylonia spirata* and *Zemiropsis papillaris* was extracted from foot tissue using an EZNA Invertebrate DNA kit following the accompanying Mollusc DNA Protocol. The partial 5' half of subunit I of the mitochondrial cytochrome *c* oxydase gene (COI) was amplified using the primers developed by Folmer *et al.* (1994), and sequenced directly (details as in Uit de Weerd *et al.*, 2004). All sequences were deposited in GenBank (acc. nos AY819772-AY819775). As an outgroup to these species and *Babylonia japonica*, we chose *Oliva sayana* and *Turbinella angulata*. COI sequences of these two outgroups were determined and analysed by Harasewych *et al.* (1997) (GenBank acc. nos U86333 and U86332, respectively). Of all potential outgroup taxa, *Oliva sayana* is considered most closely related to the ingroup on the basis of anatomical data, *Turbinella* on the basis of COI data (Harasewych & Kantor 2002). Both outgroups are placed within the superfamily Volutoidea, which also includes the ingroup species.

All sequences were aligned using the Clustal V align option in MegAlign 4.03<sup>©</sup> (DNASTAR Inc., 1999), checked for stop codons, and imported in PAUP\* 4.0b10 (Swofford, 2002). We performed maximum parsimony (MP) heuristic searches consisting of 100,000 random addition replicates (TBR, steepest descent). MP bootstrap analyses were based on 10,000 bootstrap replicates (10 random addition replicates each, TBR, steepest descent), excluding uninformative characters.

RESULTS

COI sequence length varied from 542-591 base pairs in the sequences retrieved from GenBank to 648 base pairs in all newly determined sequences. Base frequencies did not differ significantly across the taxa, neither for the total dataset (Chi-square test, *P* = 0.83) nor for a truncated dataset including positions available for all taxa only (Chi-square test, *P* = 0.87). A comparison of pairwise transitional and transversional distances versus uncorrected overall pairwise distances (Fig. 1a), revealed that transitions hardly contributed to the differences in overall pairwise distances. This phenomenon is generally attributed to extensive transitional saturation, i.e. an accumulation of transitions overwriting the phylogenetic signal (Wakeley, 1996). Based on these inferences we performed two parallel MP analyses: (1) weighing transitions and transversions equally, and (2) excluding transitions, using transversions only (cf. Milinkovitch *et al.*, 1995). Each analysis resulted in a single most parsimonious tree (Fig. 1b, c). The two trees are congruent with respect to basal relationships, both identifying *Babylonia* and *Zemiropsis* as sister groups. As expected on basis of the plot, these basal relationships are better supported when transitions are excluded (*Zemiropsis* + *Babylonia* 100 % bootstrap support vs. 99%; monophyly *Babylonia* 81% bootstrap support vs. 52%). The analyses disagree, however, with respect to the relationships within *Babylonia*. In fact, neither analysis resolves these interrelationships well (all MP bootstrap values < 70%).



**Figure 1** Phylogenetic information within the COI dataset. The distance produced by transitions (ti) and tranversions (tv) plotted against the total uncorrected pairwise distance (a). Single most parsimonious tree (score = 403), with transitions and transversions weighted equally (b). Single most parsimonious tree (score = 115) using transversions only (c). Numbers on both trees represent MP bootstrap values.

### DISCUSSION

On the basis of the molecular analyses, *Zemiopsis papillaris* has to be considered the sister group of a clade with the four *Babylonia* species that could be investigated. Obviously, these *Babylonia* species are more closely related to one another than each of them is to *Zemiopsis papillaris*. On the one hand, DNA differentiation can now be added to shell morphology and allopatric distribution as one more argument against the synonymy of *Babylonia* and *Zemiopsis*. On the other hand, the molecular data support the close phylogenetic relationship between the two taxa, i.e. as sister groups. In accordance with Altena & Gittenberger (1981) and Gittenberger & Goud (2003) and on the basis of the same arguments, supplemented by the new data, we prefer the latter alternative.



## ACKNOWLEDGEMENTS

We are grateful to Brian Hayes who sent us specimens of *Zemiropsis papillaris* for DNA sequencing.

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# EXTANT POPULATIONS OF *ORCULELLA BULGARICA* (HESSE, 1915) IN IBERIA

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**Abstract** Extant populations of *Orculella bulgarica* (Hesse, 1915) are described from Iberia for the first time. We present the first description of the reproductive system anatomy of the species, as well as the structure of the periostracum of young shells. Assignment to the genus *Orculella* Steenberg 1925 is confirmed.

The populations in Iberia are found in hygrophilous habitats such as small marshes. It is recommended that the species be classified as critically endangered based on the small size of the four known populations, three of which have disappeared in the last decade.

**Key words** *Orculella bulgarica*, anatomy, ecology, biogeography, endangered species.

## INTRODUCTION

Ninety years ago Hesse (1915) described *Orculella bulgarica* from “Beloslav, 15 km west of Varna, Bulgaria”. All specimens found have been of shells, except possibly those from Radomir, also in Bulgaria, collected by Urbanski (1960, in Gittenberger, 1983).

Modern and fossil shells have been reported up to 1983 from Bulgaria, Russia and Armenia (Likharev & Rammelmeier, 1952; Urbanski, 1960 in Gittenberger, 1983; Urbanski, 1969; Damjanov & Likharev, 1975; Akramowski, 1976). Fossil material has also been reported from the Holocene in the Spanish provinces of Barcelona (Almera & Bofill y Poch, 1898: *Pupa dolium* var. *plagiostoma* in Gittenberger, 1983), Almería (Brunnacker & Ložek, 1969: *Orcula plagiostoma*) and Granada (Madurga, 1973: *Orcula dolium*). These authors, however, only compiled and/or confirmed previous shell descriptions of the species.

In 1983, Gittenberger characterized the genera classified in Orculidae, with *Orculella* Steenberg 1925, adding several conchological features of taxonomic significance. In relation to *O. bulgarica*, this author studied shells from the archaeological site of Orce (Granada, SE of the Iberian Peninsula) that were similar to Bulgarian specimens, including the presence of microsculpture of irregular spiral ridges on the protoconch and a palatal lamella present in young specimens (but absent in the last whorl of adults).

Preece (1991) recorded *O. bulgarica* from the Spanish provinces of Guadalajara and Soria, increasing the number of Quaternary locations for the species in the Iberian Peninsula. This author found it not only in Middle Pleistocene sediments at Ambrona, but also in late Holocene sediments at Baides, showing that it had a long history in central Spain. At Baides it occurred in sediments younger than  $2640 \pm 70$  radiocarbon yr BP, leading Preece to suggest that it may well survive in Spain.

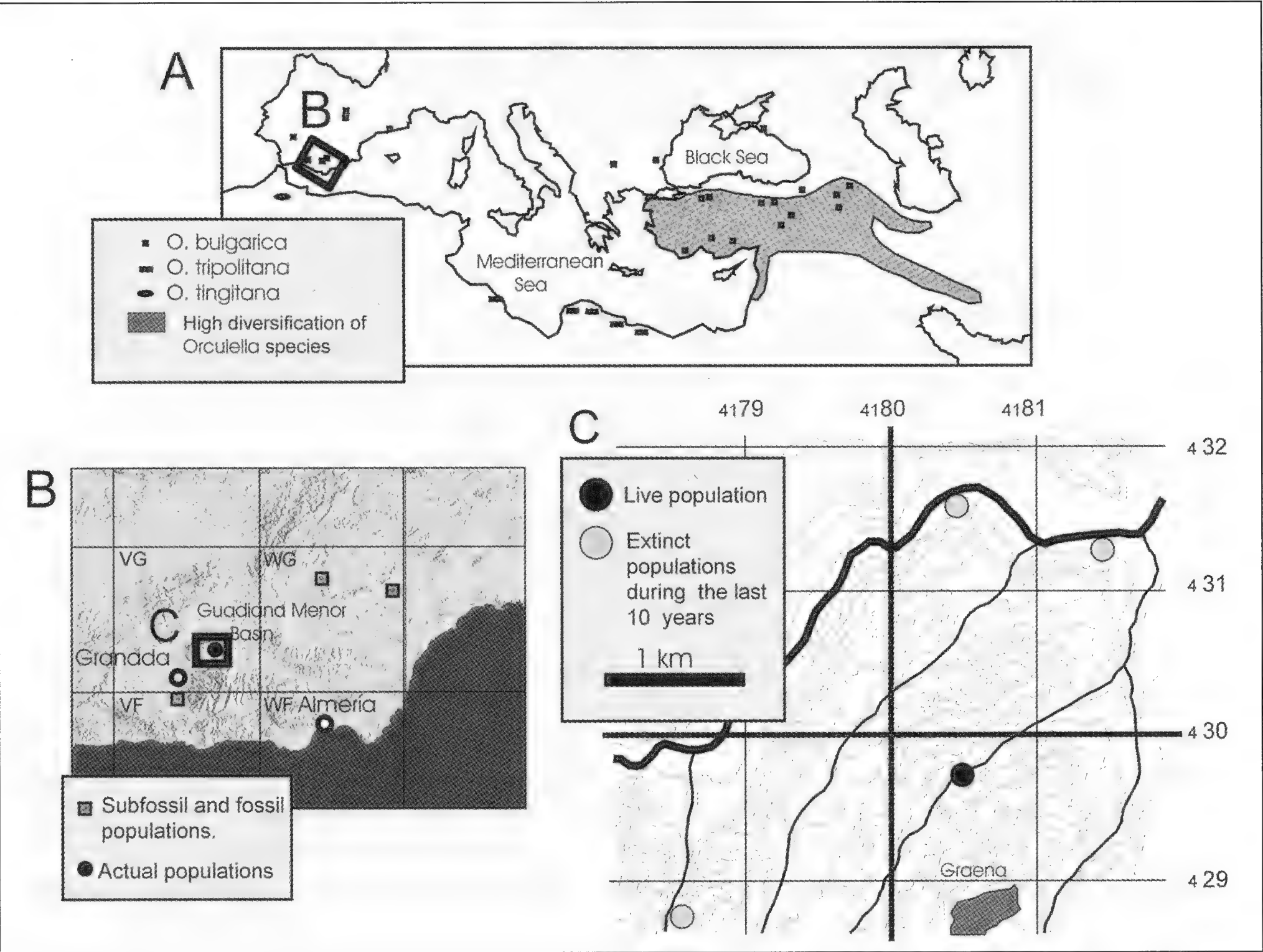
Schütt (1985, 1992 and 1993; the two latter in Hausdorf, 1996), Bank (1986) (in Preece, 1991) and Hausdorf (1996) also extended its geographical range in Turkey, based on recent shells. The last author, who carried out a complete phylogenetic study of Orculidae, proposed to differentiate *O. bulgarica bulgarica* and *O. bulgarica lamellata* based on the development of apertural structures.

Thus, these authors have contributed valuable distributional (Map 1) and conchological information on *O. bulgarica*, allowing its classification in Orculidae. The

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**Map 1** A) World distribution of three *Orculella* species, *Orculella bulgarica* (Hesse, 1915), *O. tripolitana* and *O. tingitana*, according to Gittenberger (1983), Preece (1991) and Hausdorf (1996), and the study area (B) where the only extant populations of *O. bulgarica* have been found. B) Actual and subfossil locations of *O. bulgarica* in southern eastern Iberian Peninsula according to Brunnacker & Lozek (1969), Madurga (1973) y Gittenberger (1983). C) Actual populations of *O. bulgarica* in the study area.

lack of live specimens, however, has not enabled anatomical studies to be done which are necessary to confirm assignment to the genus *Orculella*. Conflicting interpretations have been made concerning the ecological preferences of the species. This may be as a result of these preferences having been established from the sedimentary conditions where the fossil shells have been found. Thus, Gittenberger (1983) described it as a mesophile species living in woodland, whose disappearance from the localities where it has been cited as fossil would have been as a result of deforestation, and whose surviving populations (if they exist) would be located in forest and wet environments. In contrast, Preece (1991) considered it a typical species from dry habitats consistent with the depositional conditions and faunistic association where it appeared in Guadalajara (central Iberian Peninsula).

The discovery of extant populations of *O. bulgarica* in the SE of the Iberian Peninsula has allowed the shell of live juvenile specimens and the anatomy of the adult reproductive system to be described, as well as the characterization of the habitats where the populations exist.



## MATERIAL AND METHODS

The Andalusian terrestrial malacofauna (S of the Iberian Peninsula) (Map 1A) has been studied from a wide regional perspective for more than a decade (Arrébola, 1995). In addition, smaller scale studies have focused on specific areas. Some of these specific areas include the aquatic environments and riparian vegetation associated with springs, natural watercourses and traditional irrigated land systems of the Guadiana Menor river basin (Granada, SE of the Iberian Peninsula) (Maps 1B and 1C) where the present study was undertaken. The western half of this area has already produced interesting findings (Arrébola, Garrido & Bertrand, 2000).

The study area is located between low courses of the rivers Alhama de Lugros and Fardes and is characterized by a hilly topography, up to an altitude of 200 m above the narrow valleys that separate both streams (Map 1C). It is an outcrop of limestone conglomerates and Plio-Pleistocene permeable sands (Guadix Formation, Facies Pozo Halcón; 5–0,1 My BP) seated on impermeable marine marls of Tortonian age (IGME, 1980). This geological sequence has produced a number of small springs in the contact zone between both formations, which have been traditionally used for irrigation systems.

Plots ranging between 4 to 20 m<sup>2</sup> were sampled in habitats that were identified as suitable for *O. bulgarica*. These habitats were classified using criteria described in the CORINE program (European Union, 1997). The associated terrestrial malacofauna was also recorded. For conservation reasons, and because some live material of *O. bulgarica* was unfortunately lost, the anatomical study was made using only two adults and one juvenile.

## RESULTS AND DISCUSSION

### *Orculella bulgarica bulgarica* (Hesse, 1915)

*Orcula bulgarica* P. Hesse, 1915. Arch. Moll., 47:92. "Aus den Anschwemmungen des Devna-Sees bei Gebedsche" = Beloslav, 15 km west to Varna (Bulgaria).

Superfamilia Pupilloidea Turton 1831

Familia Orculidae Pilsbry 1918

Genus *Orculella* Steenberg 1925 (Bank, Bouchet, Falkner, Gittenberger, Hausdorf, Proschwitz & Ripken, 2001).

*Material examined* (sp: live collected specimens, sh: dead shells, a: adults, j: juveniles). Fuente Alta de Potrera (UTM 30SVG7828; H = 920 msnm) (7/9/1997, 17/9/2002) (28 spa + 4 spj; 4 sha + 1 shj): small spring, irrigation canal (in spanish called "acequia") and channel connecting both. Vegetation mainly composed of *Scirpus holoschoenus* L., *Elymus panormitanus* (Parl.), *Brachypodium phoenicoides* (L.) and *Rubus ulmifolius*. *O. bulgarica* specimens were in compact masses of *Chara vulgaris*, in an area of less than 4 m<sup>2</sup>. Associated terrestrial malacofauna composed of *Jaminia quadridens* (O.F. Müller, 1774), *Cornu aspersum* (O. F. Müller, 1774), *Iberus gualtieranus alonensis* (Férussac, 1821), *Cepaea nemoralis* (Linnaeus, 1758), *Oxychilus* sp., *Vitrina pellucida* (O.F. Müller, 1774), *Cochlicopa lubrica* (O.F. Müller, 1774), *Rumina decollata* (Linnaeus, 1758) and *Oxyloma elegans* (Risso, 1826).

Venta del Río de Cortes (UTM 30SVG8131; H = 860 msnm) (1997, without precise date) (1 spa + 1spj): dense grassland of *Elymus panormitanus* (Parl.) in humid or swampland of the river Fardes plain. Other terrestrial molluscs: *Monacha cartusiana* (O.F. Müller,

1774), *Theba pisana* (O.F. Müller, 1774), *Cochlicella* (*Prietocella*) *barbara* (Linnaeus, 1758) and *Oxychilus* sp.

Fuente Seca de Cortes (UTM 30SVG8031; H = 880 msnm) (13/5/2000) (9 sha + 6 shj): small spring and irrigation canal previously surrounded by bulrushes (*Scirpus holoschoenus* L.) that were removed during agricultural works. Recent shells of *O. bulgarica* were found in the rootless bulrushes piled up next to the irrigation canal. Other terrestrial molluscs were *C. aspersus*, *I. g. alonensis*, *C. nemoralis*, *R. decollata*, *M. cartusiana*, *C. barbara*, *Cochlicella acuta* (O.F. Müller, 1774) and *O. elegans*.

Fuente de la Rambla de la Viña (UTM 30SVG8029; H = 940 msnm) (22/04/04). (1 spa + 1 sha): reed bed dominated by common reed *Phragmites australis* (Cav.) growing in the slightly swampy soil at the bottom of the valley. Specimens collected under a mix of soil and common reed roots that had been removed during the cleaning of a small drainage channel of the spring. Other snails: *C. lubrica* and *C. barbara*.

*Measurements of adults shells* (N= 42). Height= 6.15–8.15 mm (mean= 6.93 mm). Width= 3.0–3.3 mm (mean= 3.14 mm). Aperture maximum width= 1.25–2.05 mm (mean= 1.93 mm).

*Shell* (Fig. 1). Conical-oval in shape, dark brown in colour and somewhat translucent (Fig. 1A). Protoconch with 1 ½ to 1 ¾ whorls and fine microsculpture of irregular spiral ridges on the surface (Fig. 1B), more accentuated at the periphery, but absent in the teleoconch (Fig. 1C). 7 ¼ to 9 ¼ slightly convex body-whorls with slow and fairly regular growth and shallow sutures (Fig. 1C). Last whorl slightly raised near the peristome and larger than the previous one. Shell surface partly covered with dense, fine, transverse ribs (Fig. 1C). Small umbilicus that is elongated, narrow and shallow. Aperture more or less rounded, somewhat taller than wide (Fig. 1A). Peristome interrupted, thickened, without (or with a very weak) parietal callosity and slightly reflected, especially in the umbilical area. Palatal wall slightly concave with a crenulated edge laterally. Adults with only a short and small parietal lamella originating some distance from the edge, internally extended ½ whorl. Juveniles with both fine columellar and parietal lamellae on the aperture (see Gittenberger, 1983), a rounded and deep umbilicus and sculpture made up of thin, oblique ribs in the shape of platelets which are lost in the adult stages (Figs. 1D-E).

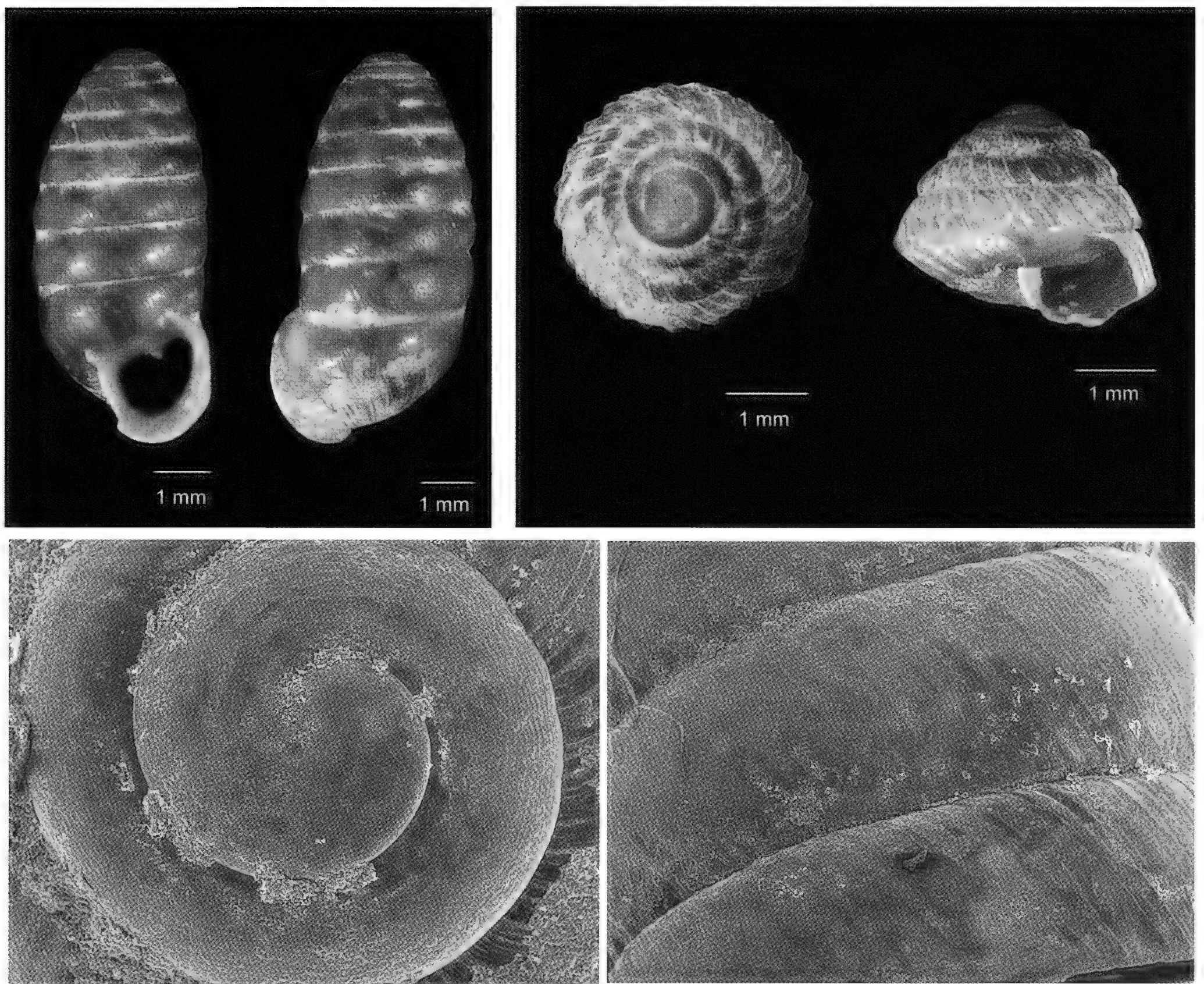
*Reproductive system* (Fig. 2) Right ommatophore retractor muscle going through penis and vagina. Atrium small. Penis short (1,1 and 1,3 mm) with distal part somewhat longer but thinner than proximal one. Penial appendix relatively long (4-5 mm) and of variable width, with first half thicker than second half, despite slight terminal enlargement. Penial caecum quite simple and short (0,5 mm) with a small penile retractor muscle at its base. Epiphallus as long and thick as penis, or somewhat longer and thinner. Bursa copulatrix and duct long (5 mm) and not well differentiated from one another, although there is a small constriction in front of the elongated bursa. Free oviduct, vagina short and thick.

*Geographical range* Bulgaria, the Caucasus, Turkey and Spain (see Introduction).

#### TAXONOMICAL IMPLICATIONS

The shell features described are in general agreement with those given by Gittenberger (1983), Preece (1991) and Hausdorf (1996) including the apertural modifications of juveniles and adults (see the latter reference for details of the subspecies *O. bulgarica bulgarica*). The main differences relate to a somewhat more slender shape of the shells in comparison with the figure published by Gittenberger (1983, fig. 2, page 330) and a





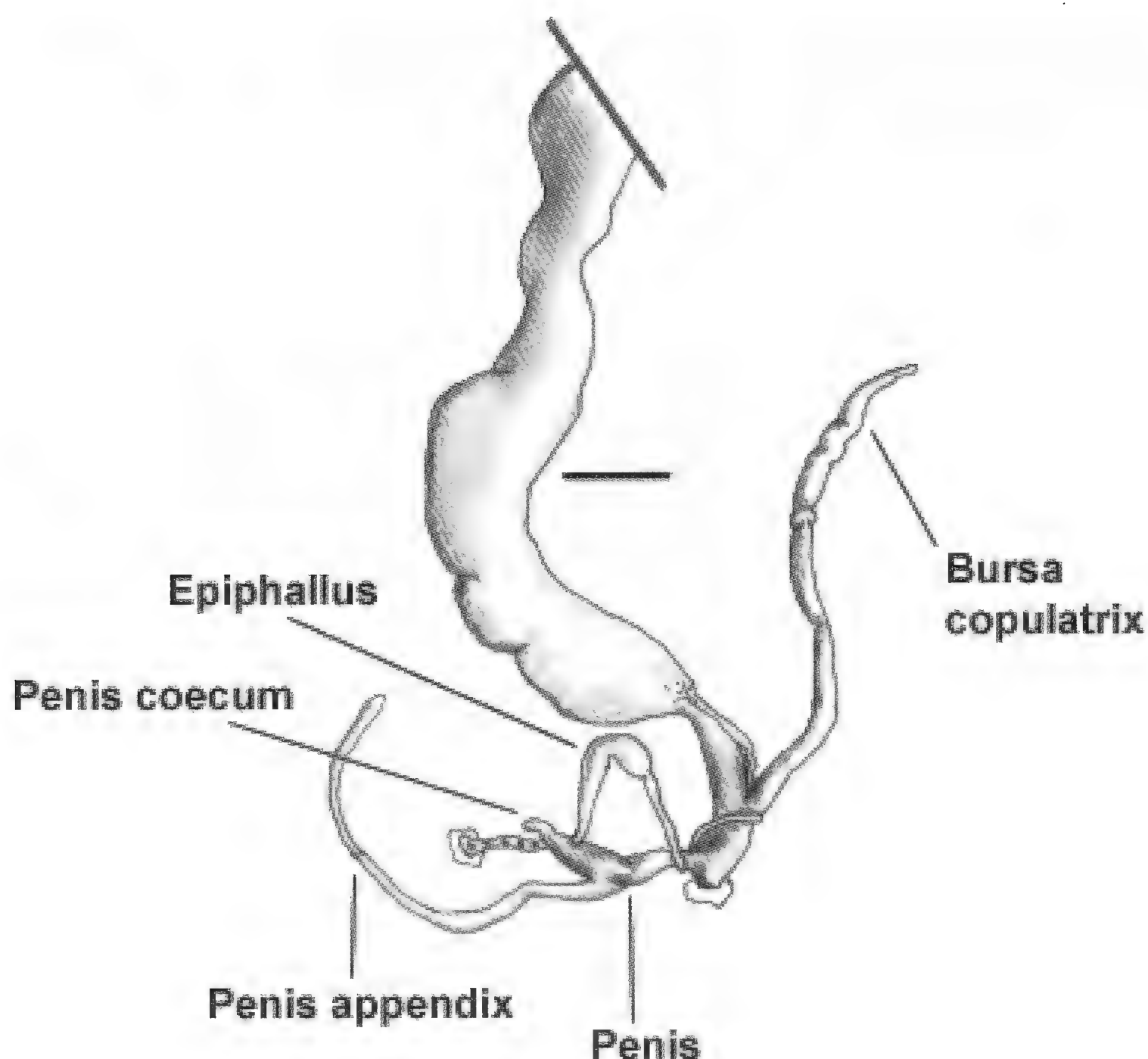
**Figure 1** Images of *Orculella bulgarica* (Hesse, 1915) shell. **A** Front and rear views. **B** Frontal and upper views of a recent juvenile shell showing the oblique ribs in the shape of platelets (arrow). **C** Protoconch **D** Whorls.

less pronounced apical microsculpture (Preece, 1991, fig. 10, 4 b-c). Flat, thin and oblique ribs observed in juveniles shell have not been described before, possibly because the ribs are worn away in adult and dead shells.

The anatomical study confirms the correct assignment of this species to the genus *Orculella*. This is characterized, in relation to the closest genera of Orculidae (Bank *et al.*, 2001), by the direct insertion of the penis retractor muscle in the penis, instead of the ephiphallus, as occurs in *Schileykula* Gittenberger 1983, *Alvariella* Hausdorf 1996, *Sphyradium* Charpentier 1837, *Pilorcula* Germain 1912 and *Pagodulina* Clessin 1876 and by the presence of the penial appendix, absent in *Orcula* Held 1838 (Hausdorf, 1996). A more detailed differentiation, including conchological features, can be found in Gittenberger (1983) and Hausdorf (1996).

The only other *Orculella* species having both short penis and reduced penial caecum (Hausdorf, 1996; Schütt & Sessen, 1998), similar to *O. bulgarica* (1,1-1,3 mm and 0,5 mm of length, respectively), are *O. pfeiferi* Hausdorf, 1996 (1,1-2,2 and 0,4-0,6 mm, respectively) and, to a lesser extent, *O. ruderalis* Akramowski, 1947 (1,4 and 1,1 mm) (Hausdorf, 1996: Tab. 2, pag. 23). However, in both these species, the dimensions of the penial appendix and epiphallus are several times greater than the same structures in *O. bulgarica*. In species with similar penial appendixes sizes, such as *O. menkhorsti*





**Figure 2** Reproductive system of *Orculella bulgarica* (Hesse, 1915), Fuente de la Rambla de la Viña in Granada (SE of Iberian Peninsula) (UTM 30SVG8029). Scale= 1 mm.

Hausdorf, 1996 and *O. sirianocoriensis* (Mousson, 1854), the penial caecum are much longer than in *O. bulgarica*. The identity of *O. bulgarica* is derived here from anatomical as well as conchological features, the latter being the taxonomical features traditionally used.

#### ECOLOGICAL AND PHENOLOGICAL CHARACTERISATION

*O. bulgarica* was found in permanently moist or waterlogged soil habitats in permanent springs in areas of limestone. These areas belong in the ecosystems complex associated with alkaline fens (CORINE code: 54.2) and petrifying springs with tufa formation (CORINE code: 54.12) and, more specifically, oligo-mesotrophic waters with benthic vegetation of *Chara* spp. (CORINE code: 22.12x22.44), mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion* (community of *Elymo-Brachipodietum phoenicoidis*) (CORINE code: 37.4), common reed formations (*Phragmites australis*) (CORINE code: 53.1) or denuded and swamp slopes. These are mostly undisturbed areas, with the exception of some isolated cases where vegetation has been removed (e.g. bulrushes) for traditional irrigation systems.

Wet plant material on the soil surface would be used by *O. bulgarica* as food, for reproduction and resting areas during activity stages, whilst the more dense masses represented by roots and stems of bulrushes may be important refuges during periods of dormancy. In common with other Mediterranean areas, land mollusc activity occurs in autumn and spring, whereas dormancy occurs in winter (hibernation) and summer (aestivation). Some *O. bulgarica* individuals were active under water and on floating masses of *Chara vulgaris*.

TABLE 1

Bioclimatic characterization, according to Rivas-Martínez (2000), of meteorological stations near localities where *O. bulgarica* specimens have been captured alive (S. of Iberian Peninsula), or where fossil shells have been collected (Bulgaria, Turkey and Caucasus region) (H: altitude in metres; T: temperature in degrees Centigrades; P: precipitation in millimetres).

Meteorolological station	Geographical Coordinates	H (m)	T (°C)	P (mm)	Nº dry months	Termo-ombroclimate type
Guadix (Spain)	37°18' N 3°08' E	900	14,1	321	4	Upper Mesomediterranean Upper Semiarid
Batumi (Georgia)	41°39' N 41°38' E	6	15,3	2214	0	Upper Thermotemperate Low Hyperhumid
Zakataly (Azerbaijan)	41°38' N 46°39' E	518	13,1	855	1	Low Mesotemperate Upper Subhumid
Yerevan (Armenia)	40°08' N 44°28' E	907	13,0	262	4	Upper Mesomediterranean Upper Semiarid
Trabzon (Turkey)	41°00' N 39°46'E	34	15,5	799	1	Upper Thermotemperate Low Subhumid
Tbilisi (Armenia)	41°14' N 44°57' E	490	12,6	518	1	Upper Mesomediterranean Upper Dry
Sofija (Bulgaria)	42°42' N 23°20' E	550	10,4	622	0	Low Supratemperate Low Subhumid

Species associated with *O. bulgarica* may be grouped into three categories: (1) species closely related with aquatic or hygrophilous environments throughout their range, (2) generalists in the Eurosiberian region, but living in humid habitats in the Mediterranean region and, (3) species that have wide ecological requirements in southern Iberia but are limited to humid areas (such as irrigated fields) by the dry/semiarid ombroclimatic conditions of the Guadiana Menor depression (see meteorological data from Guadix, Table I). *C. lubrica* (Gómez, 1988; Altonaga *et al.*, 1994) and *O. elegans* belong to the first category, *C. nemoralis* (Arrébola *et al.*, 2000), *M. cartusiana* (Ramos y Aparicio, 1985; Prieto, 1986) and *V. pellucida* (Arrébola *et al.*, 2000) to the second, and *C. aspersum*, *R. decollata*, *P. barbara*, *C. acuta* and *T. pisana* (Arrébola, 1995 and unpublished data) to the third. The sporadic appearance of xerophile species, such as *J. quadridens* and *I. g. alonensis* may be explained by their use of habitats as refuges or for food resources during the dry season or, alternatively, by their introduction after falling from the rocky and dry surroundings.

The lack of data from other modern populations of *O. bulgarica* prevents the assignment of mesophilic or xerophilic preferences for this species as proposed by Gittenberger (1983) and Preece (1991) for fossil or subfossil populations. On the other hand, the hygrophilic preferences identified for the modern populations may reflect a common behaviour for the species or an adaptation to the Mediterranean climate, similar to that displayed by *C. nemoralis* and *V. pellucida* (Arrébola *et al.*, 2000). Bioclimatic data (Rivas-Martínez, 2000; Table 1) from localities near those where *O. bulgarica* specimens

have been found alive (S. of Iberian Peninsula) or where fossil shells have been collected (Bulgaria, Turkey and Caucasus region), indicate that this species always appears in areas of mild temperatures (T between 10,4 °C and 15,5 °C), with wide tolerance to rainfall (P between 262 mm and 2.214 mm; 0 to 4 dry months). This suggests the species has restricted thermoclimatic tolerances (a stenotherm species *sensu* Rousseau, 1989), preferring humid/sub-humid environments (i.e. coastal populations of Black Sea). Semi-arid environments would restrict the species to habitats with humidity during the summer months, as is the case with the Guadiana Menor populations.

#### BIOGEOGRAPHICAL CHARACTERISATION AND CONSERVATION

The distribution map compiled by Gittenberger (1983), along with the findings of Preece (1991) and Hausdorf (1996) (Map 1A), indicate a circum-mediterranean distribution for *O. bulgarica*, with fossil populations in Anatolia, Caucasus, Transcaucasus and the Balkans, and fossil and modern populations in the Iberian Peninsula. Aside from *O. tingitana* (Pallary, 1918) and *O. tripolitana* (von Brandt, 1956) that live in NW Africa, other taxa classified as *Orculella* seem to be concentrated in Anatolia and in the Caucasus region, representing the main diversification area of the genus with about 15 species (Gittenberger, 1983, Hausdorf, 1996).

In the absence of adequate palaeontological data it is difficult to determine the origin and expansion of *O. bulgarica*. It may originate from the north-eastern Mediterranean region where both the genus and species show the greatest diversification. The existence of *O. bulgarica* / *O. tingitana*-*O. tripolitana* on both sides of the western Mediterranean may signify an ancestral expansion from the Mediterranean basin during the Messinian, with later isolation and divergence leading to three species. The effects of the Messinian Salinity Crisis, along with glaciation during the Pleistocene and general anthropic influences, have been defined as the most important events structuring the Mediterranean biota (Blondel y Aronson, 1999).

*O. bulgarica* is a rare species in decline (Hausdorf, 1996), that survives in small relict populations in natural or moderately disturbed habitats. Other than an early reference to live specimens from Radomir (Bulgaria) (Urbanski, 1960 in Gittenberger, 1983) where this species has not been found alive since, the only known extant population is that from Granada (Guadiana Menor river basin).

During the last 7 years all known populations, except that at La Rambla de la Viña, have been destroyed. But even this locality may be destroyed because of habitat exploitation. *O. bulgarica* has an estimated area of occupancy of less than 10 km<sup>2</sup> and is in decline both in terms of number of localities where it occurs and decreases in its populations. The species should thus be considered as "Critically Endangered" and included in the Habitats Directive Annex II and IV of the European Union. The Andalusian Regional Ministry of the Environment is already taking action to afford this species, and its habitats, appropriate protection.

#### ACKNOWLEDGEMENTS

Thanks are due to Alex Menez from Gibraltar Museum who corrected the last English version. Ivo Dedov from Sofia (Bulgaria) who provided us with some of the bibliography. Professor Rafael Delgado and Rocío Márquez, from the Faculty of Pharmacy (University of Granada), who took the shell microstructure photographs. This study forms part of the "*Program for Conservation and Sustainable Snail Exploitation in Andalucía*" supported by the Andalusian Regional Ministry of the Environment.



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# A NEW SPECIES OF THE GENUS *FLABELLINA* VOIGT, 1834 (MOLLUSCA: NUDIBRANCHIA) FROM THE CAPE VERDE ISLANDS

CALADO, G.<sup>1,2</sup>, ORTEA, J.<sup>3</sup> & CABALLER, M.<sup>4</sup>

**Abstract** A new species of the genus *Flabellina* Voigt, 1834 with perfoliated rhinophores is described from Cape Verde Islands. Its main external characteristic is the colour pattern of the rhinophores and oral tentacles. These exhibit a broad central purple ring, an opaque upper white region and a translucent pink basal region. This species is compared with the other three Atlantic species of the genus with perfoliated rhinophores: *Flabellina engeli* Marcus, 1968, from the Caribbean Sea, *Flabellina babai* Schmekel, 1972 from the Mediterranean Sea and Northeast Atlantic and *Flabellina llerae* Ortea, 1989 also described from Cape Verde.

**Key words** Mollusca, Nudibranchia, *Flabellina ilidioi*, new species, Cape Verde.

## INTRODUCTION

The genus *Flabellina* Voigt, 1834 includes many species with very distinctive morphological characters, including some of the most primitive eolids (Gosliner & Kuzirian, 1990). The morphology of the rhinophores is very variable. These structures can be smooth, annulated, perfoliated or with papillae (Gosliner & Willan, 1991). The condition "smooth" is considered by these authors as ancestral, although Ortea, Caballer & Moro (in press) disagree with this opinion.

So far, the species assigned to this genus in the Atlantic Ocean (including the Mediterranean and the Caribbean Sea) which possess perfoliated rhinophores are *Flabellina engeli* Ev. Marcus & Er. Marcus, 1968, *Flabellina babai* Schmekel, 1972 and *Flabellina llerai* Ortea, 1989. Two of them (*F. engeli* and *F. llerai*) were recently studied, together with other seven Atlantic species by Ortea & Espinosa (1998) and grouped together according the morphology of the rhinophores. *F. babai* is redescribed by García-Gómez (1986) from specimens collected in the Strait of Gibraltar. More recently it was sighted in strictly Atlantic waters, along the Portuguese western coast (García-Gómez *et al.*, 1991; Calado & Urgorri, 1999; Calado *et al.*, 1999; Calado *et al.*, in press).

In this paper we describe a new species of *Flabellina* with perfoliated rhinophores, collected in the Cape Verde archipelago. This new species is compared with the other three species of the genus in the Atlantic region with the above character. A comparative study of the hard parts of the buccal apparatus (jaws and radula) is also presented for the four species.

## SYSTEMATICS

Family Flabellinidae Marcus & Marcus, 1967  
Genus *Flabellina* Voigt, 1834

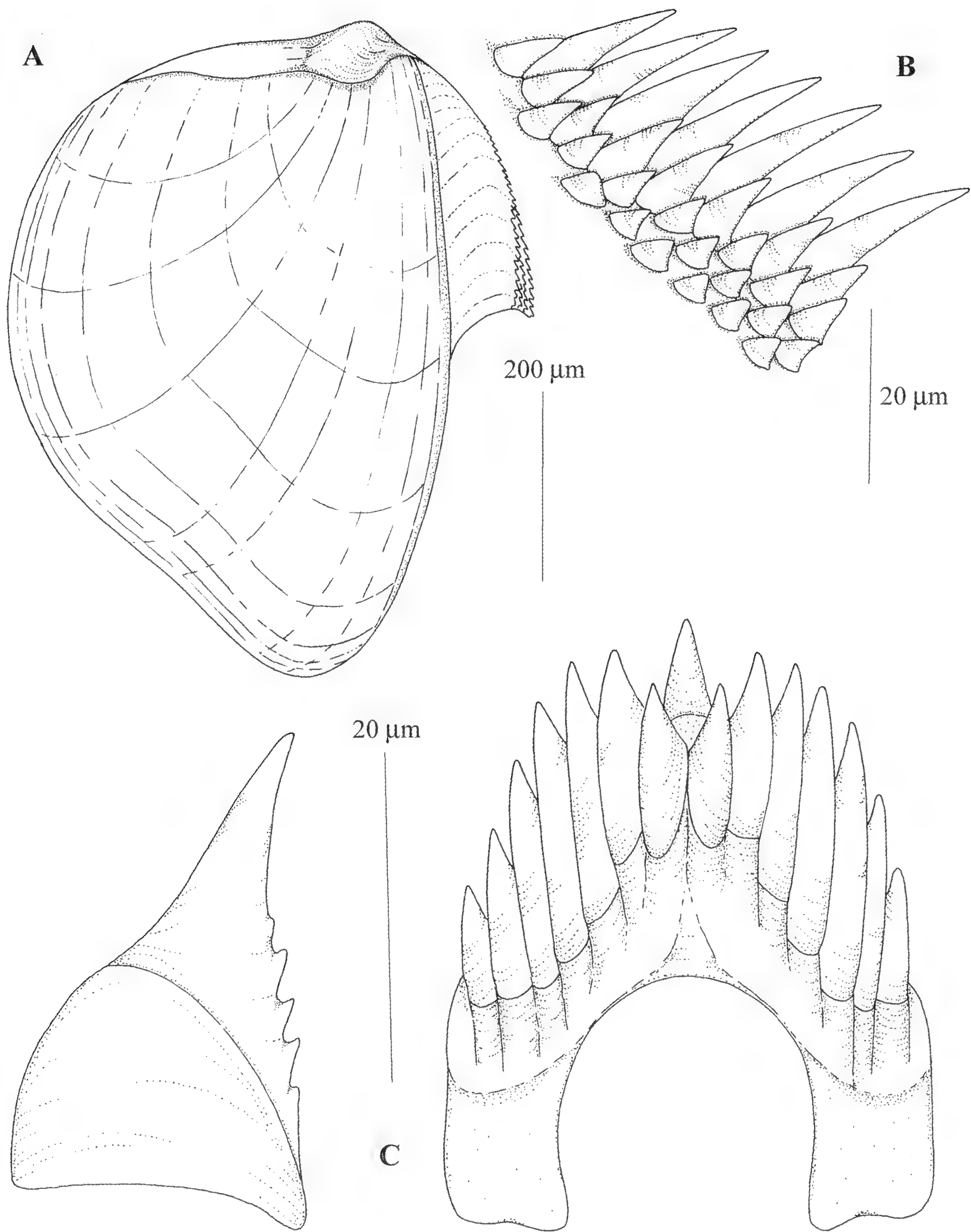
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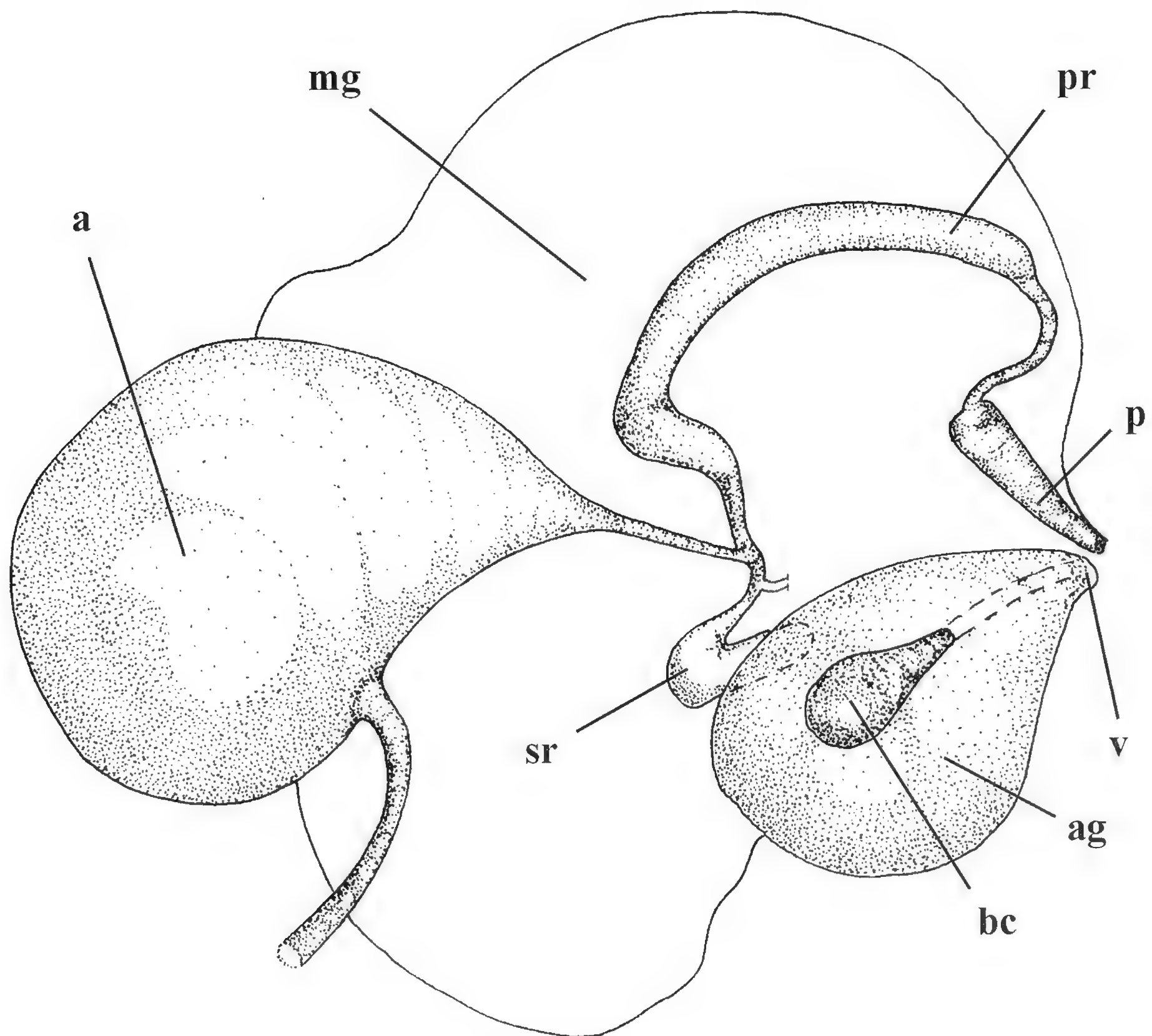
**Figure 1** A-C, *Flabellina ilidioi*, new species, A, jaw, B, masticatory border of the jaw, C, radular teeth.

*Flabellina ilidioi* new species  
(Figs.1,2. Plate. 1A)

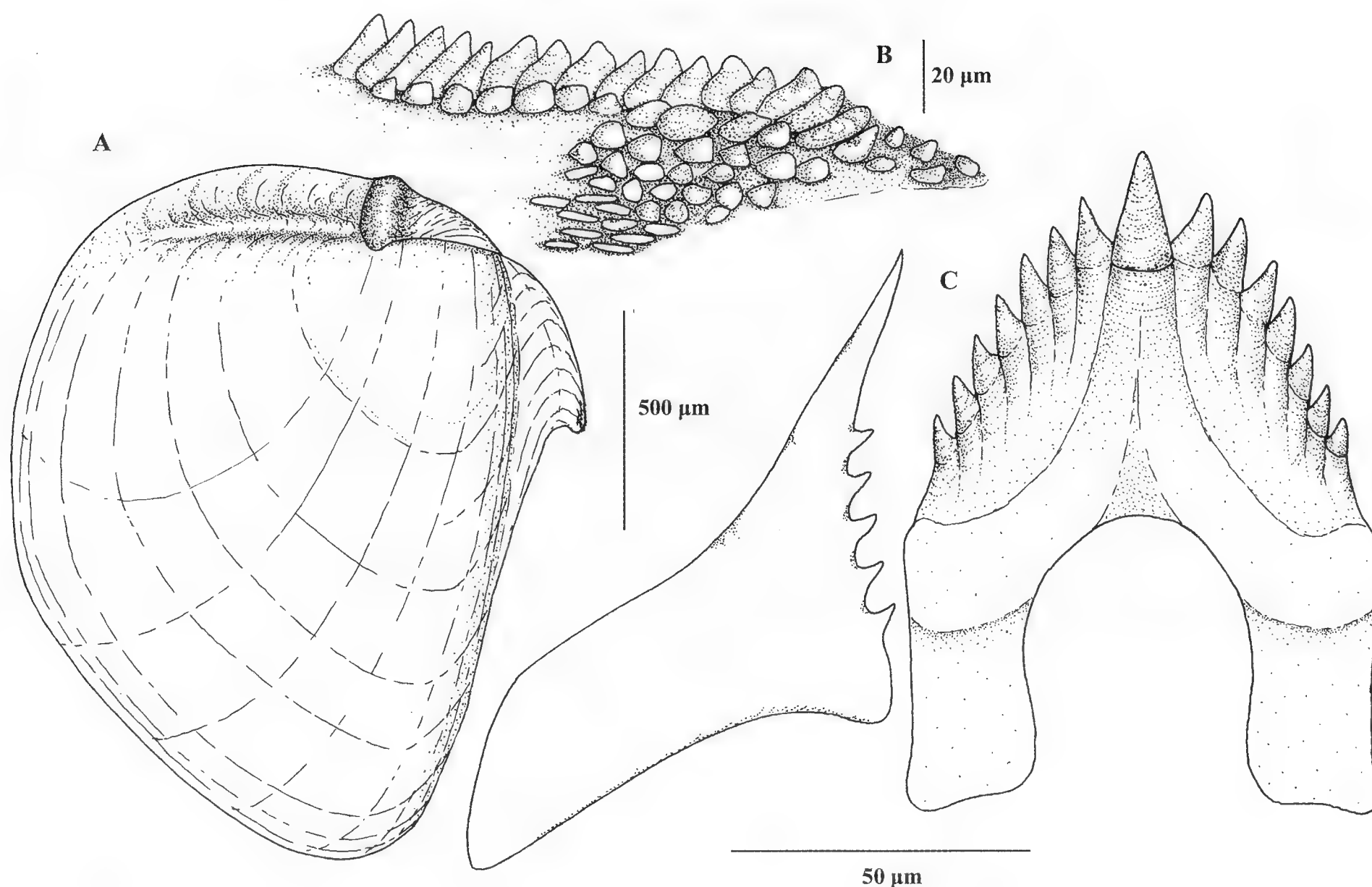
*Holotype* Specimen 6.2 mm preserved length, deposited at the Museo Nacional de Ciencias Naturales (MNCN), Madrid, Spain, with the registration number MNCN 15.05/46635.

*Paratypes* 1 Animal 5.1 mm preserved length, deposited at the Instituto Português de Malacologia (IPM), Albufeira, Portugal, with the registration number IPM.002T.MO. The remaining three specimens in the type series are also deposited at IPM, Portugal. Two of these (6.0 mm and 6.7 mm preserved length) were dissected to study the cerata arrangement, jaws, radula and reproductive system.

*Other material* All specimens from Baía da Fateixa, southern side (Type locality), S. Vicente Island, Cape Verde, in 3 October 2002. Five specimens (3.9 – 6.7 preserved length) collected on hydrozoans at 6m depth in a vertical wall.



**Figure 2** *Flabellina ilidioi*, new species, reproductive system: a, ampulla; ag, albumen gland; bc, bursa copulatrix; mg, mucus gland; p, penis; pr, prostate; sr, seminal receptacle; v, vagina



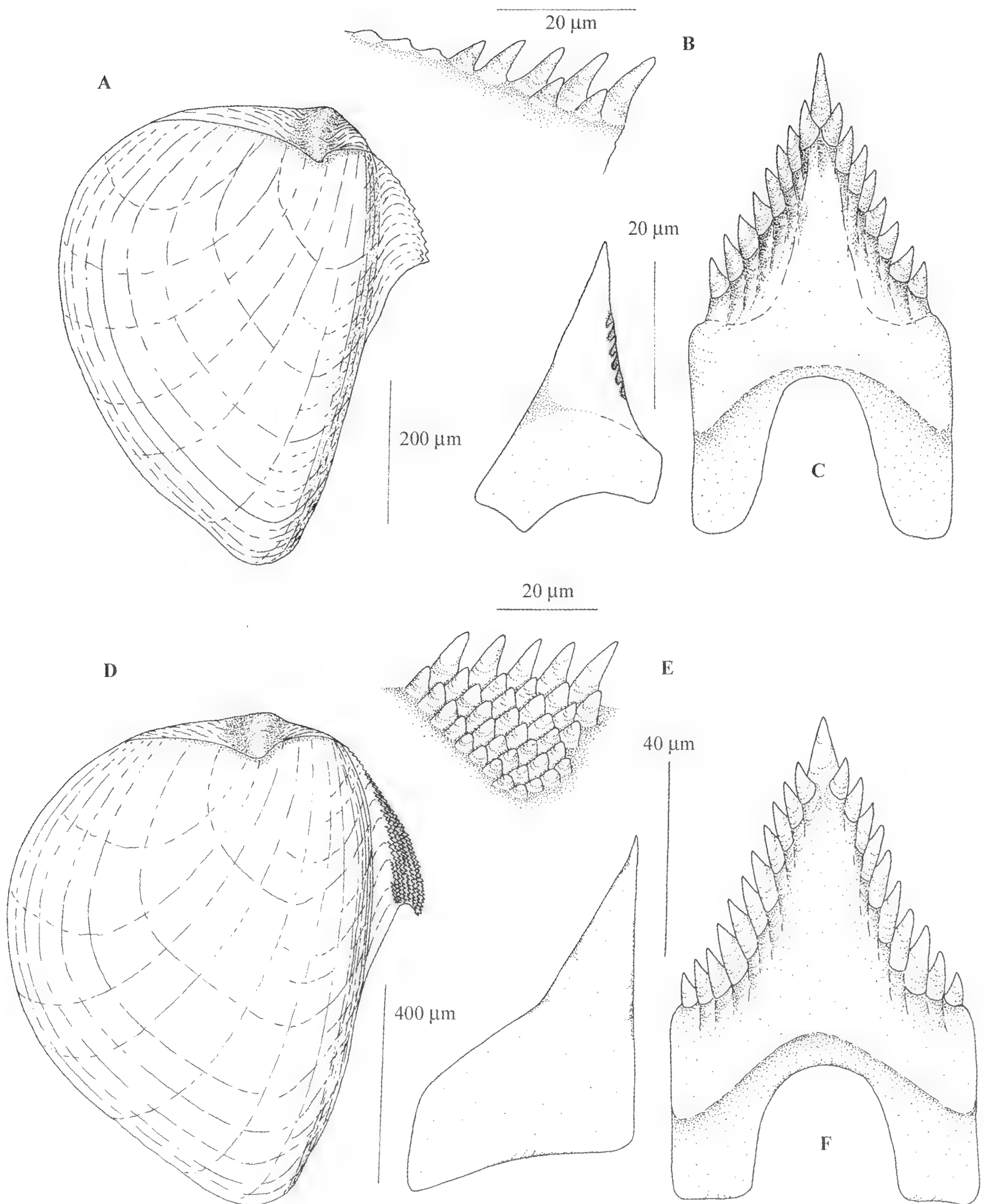
**Figure 3** A-C, *Flabellina babai*: A, jaw, B, masticatory border of the jaw, C, radular teeth.

*Other material examined* *Flabellina engeli* Marcus, 1968, one specimen 9mm in life, collected in Manzanillo, Caribbean Sea of Costa Rica (INBioCRI001497402). *Flabellina babai* Schmekel, 1972, one specimen 16mm preserved length from Ceuta, Spain 27 October 1986; two specimens 16 and 20mm preserved length from Sagres, Portugal, 4 June 2004. *Flabellina llerae* Ortea, 1989, one specimen 15mm in life collected in Sal Rei, Boavista Island, Cape Verde, April 1988; three specimens 7.2 to 9.0 preserved length from Baía da Fateixa, southern side, S. Vicente Island, Cape Verde, in 3 October 2002, collected during the same sampling trip in which the specimens of the new species were found.

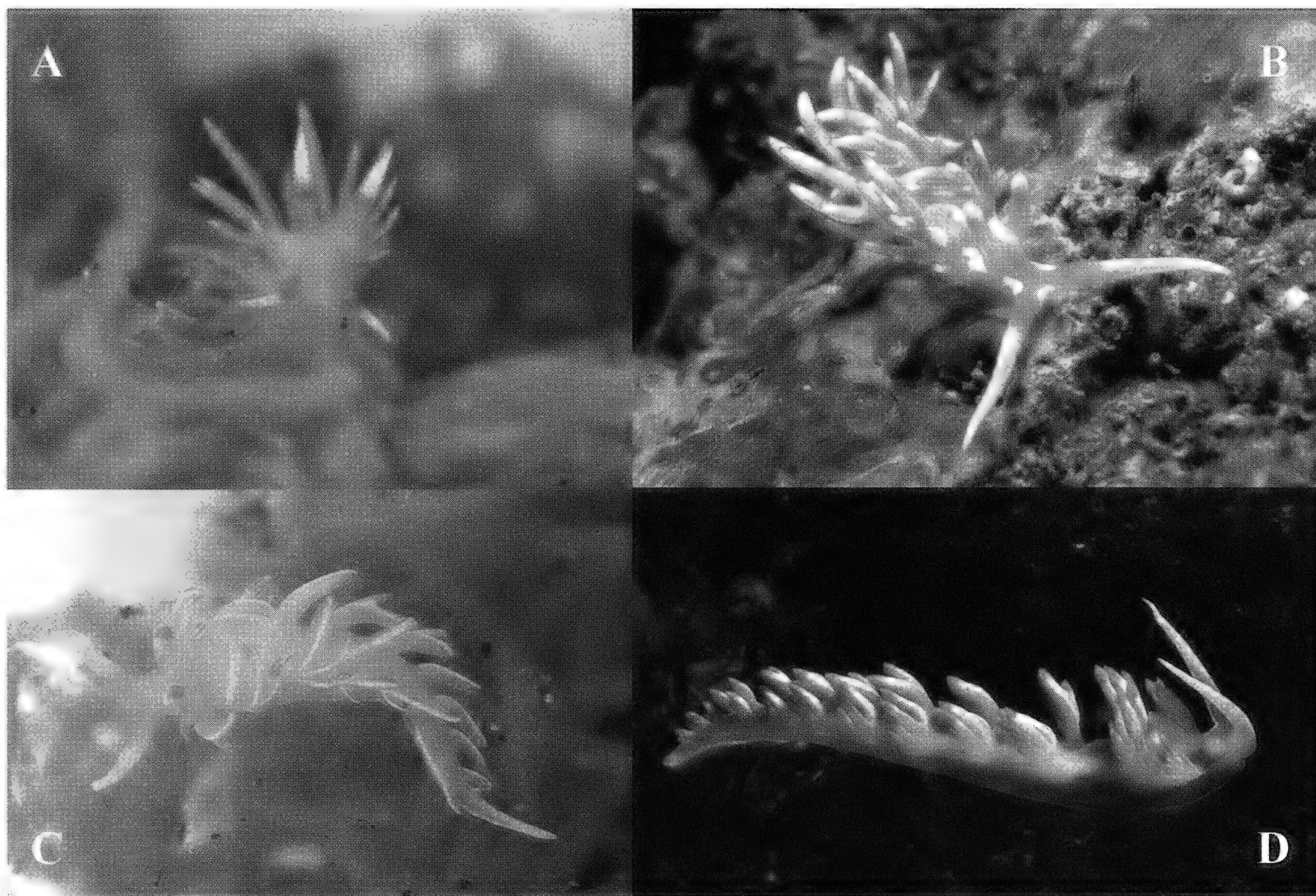
*Description* The body is generally of a translucent pale pink colour. Some inner organs are easily seen through the integument. Rhinophores are perfoliated, with 15-20 rhinophoral sheaths. These have an opaque white distal third and a dark violet central region. The basal part has the same colour of the body. Their apex is hyaline white. Oral tentacles are similar in size to the rhinophores. The basal part also has the same colour of the body. Apical region is opaque white and a dark violet band is arranged in their middle region. Propodial tentacles have the same colour of the body. Cerata arranged into 7-8 pairs of groups with one, two or three peduncles that arise from a common base. The disposition of the right hand side cerata in the 6.0 mm specimen is, from front to rear: 8,7,6,5 cerata in two peduncles, then 2 and 1 in one peduncle. In the 6.7 specimen the disposition was 8, 8 cerata in three peduncles, 4, 4 cerata in two peduncles and 2,1,1 cerata in one peduncle. An unpaired single central cerata was observed in both specimens at the rear part of the dorsum.

External colour of the surface of the cerata is the same of the body, but the reddish-orange digestive gland can be seen by transparency. The cnidosac is glossy white. The genital pore opens ahead of the first group of cerata, on the right hand side, just below the pericardium.





**Figure 4** A-C, *Flabellina engeli*: A, jaw, B, masticatory border of the jaw, C, radular teeth; D-F, *Flabellina llerae*: D, jaw, E, masticatory border of the jaw, F, radular teeth.



**Plate 1** A, *Flabellina ilidioi*, B, *Flabellina engeli*, C, *Flabellina llerae*, D, *Flabellina babai*.

In its internal anatomy, this species possess a pair of wide, chitinous jaws (850  $\mu\text{m}$  long by 650  $\mu\text{m}$  wide in the 6.7 mm long specimen and 700  $\mu\text{m}$  long by 565  $\mu\text{m}$  wide in the 6.0 mm long specimen). The masticatory border of those has five rows of denticles in the distal part. They are long and sharp in the outermost row, more eroded in the inner ones. In the innermost row they are wider than longer (figure 1, A,B). Radular formula is 33 x 1.R.1 (specimen 6.7mm long) and 30 x 1.R.1 (6.0 mm long specimen). The rachidian teeth have 6-9 lateral denticles, progressively larger as they are farther away from the central cusp. The larger ones are 56  $\mu\text{m}$  long by 40  $\mu\text{m}$  wide in the 6.7 mm specimen and 37  $\mu\text{m}$  long by 31  $\mu\text{m}$  wide in the 6.0 mm specimen. Lateral teeth have three large denticles below the cusp, occasionally accompanied by other smaller denticles, one at each side of those more developed; these teeth are 40  $\mu\text{m}$  long by 30  $\mu\text{m}$  wide in the 6.7 mm specimen and 29  $\mu\text{m}$  long by 18  $\mu\text{m}$  wide in the 6.0 mm specimen. The reproductive system (figure 2) has a massive ampulla and a long, not very folded, prostate. The seminal receptacle is not divided and the bursa copulatrix is pyriform, with a thick vaginal duct that appears embedded in the albumen gland. The connections of the seminal receptacle and the vagina could not be observed in the dissections as they were also embedded in mucus and albumen glands. Nevertheless, the general structure of the reproductive system appears to be very similar to that of *Flabellina affinis* as presented by Cervera et al. (1998).

*Derivation of name* This species is named after Ilídio A. de V. Félix-Alves, founder of the Instituto Português de Malacologia (Portuguese Institute of Malacology) and a great promoter of the Portuguese Malacology, deceased in May 2001.



Table 1 – Main characters of Atlantic *Flabellina* species with perfoliated rhinophores.

Species	External features					Radula		
	Ground Body colour	Colour of the cerata	Colour of the Rhinophores	Colour of the oral tentacles	Number of rhinophoral sheaths	Rows of radular teeth	lateral denticles of the rachidean tooth	Inner edge of the lateral radular teeth
<i>F. engeli</i>	Light violet, orange or yellow patches	Light violet, yellow or orange and reddish	Light violet and salmon rose	Light violet and white	30	19	8-11	Smooth with ventral striations
<i>F. babai</i>	White	White and orange	White and orange	White	20-27	24-35	7-10	With 6-8 denticles
<i>F. llerai</i>	Violet pink	Violet pink, dark lilac, white line	Violet pink, and dark lilac	Violet pink and white	17-18	23	10-11	Smooth
<i>F. ilidioi</i> n.sp.	Pale pink	Pale pink	Pale pink, dark violet and white	Pale pink, dark violet and white	15-20	30-33	6-9	With 3 big, occasionally 2 smaller ones

Table 1 (continued)

Species	Jaws, Masticatory border	Reproductive system				Known geographical range	Sources
		Ampulla	Bursa copulatrix	Seminal receptacle	Prostate		
<i>F. engeli</i>	Little denticulated	Two lobes	absent	Undivided	U - shaped	Caribbean Sea	Marcus & Marcus, 1968; Ortea & Espinosa, 1998 ; this study.
<i>F. babai</i>	Densely denticulated	Tubular, 4-folded	Probably absent	Ellipsoid, not pedunculated	U - shaped	NE Atlantic (Portugal and Spain) and Mediterranean	Schmekel, 1972; García-Gómez, 1986; Calado & Urgorri, 1998 this study.
<i>F. llerai</i>	5 rows of spikes and	-	-	-	-	Cape Verde, Príncipe Island	Ortea, 1989; Ortea & Espinosa, 1998; Wirtz 2004; this study.
<i>F. ilidioi</i> n.sp.	2 of plates 5 rows of denticles	Massive	Pyriform	Undivided	Long, not very folded	Cape Verde	This study



## DISCUSSION

The four Atlantic species of the genus *Flabellina* with perfoliated rhinophores (plate 1) are easily distinguishable by their body colour. We highlight the following features: the golden yellow patches in the dorsum of *F. engeli*, sometimes forming a conspicuous X-shape; the hyaline white body colour of *F. babai*, with white opaque white lines that run the anterior region of the cerata and orange tips in the cerata and rhinophores; the opaque white longitudinal line in the cerata and the violet apex of cerata and rhinophores of *F. llerae* and the dark violet transverse band between pale pink and white in the rhinophores and oral tentacles of *F. ilidioi*, new species. According to our observations, the hard parts of the buccal apparatus are also consistently different in the four species. The jaws have a masticatory border little denticulated in *F. engeli* (figure 4, A,B), very denticulated in *F. llerae* (figure 4 D,E) and *F. babai* (figure 3, A,B), whereas in *F. ilidioi*, new species (figure 1, A,B), it presents an intermediate pattern. In a dorsal view, the lateral teeth of the radula have a cutting border with thick denticles below the cusp in *F. ilidioi*, new species (figure 1, C) and *F. babai* (figure 3, C), being smooth in *F. llerae* (figure 4, F) and in *F. engeli*. In this later species there is a ventral striation that can be seen in the cutting border forming 5-6 denticles, according to the position of the observer (figure 4, C). This feature is sometimes missed when only a dorsal view of the structure is adopted. Something similar occurs in *Flabellina baetica*, originally described as having the lateral radular teeth with a smooth border (García-Gómez, 1984). In fact, it has fine denticles that are only observed when a tooth is lifted up and turned backwards (Ortea and Espinosa, 1998). Table 1 summarizes and compares the most important morphological characters of the four species studies herein.

## ACKNOWLEDGMENTS

We thank our colleague Leopoldo Moro for his collaboration and the photo of *F. engeli*. Fátima Martins provided the photo of *F. babai*. Gonçalo Rosa and Paulo Granja helped with the logistics in the field trip to Cape Verde in 2002. Samples from Costa Rica were obtained under the research project *Development of Biodiversity Knowledge and Sustainable Uses in Costa Rica* funded by the Dutch government and carried out with the support of MINAE. First author holds a grant from the Fundação para a Ciência e Tecnologia, Portugal (BPD7133/2001). Dr Juan Lucas Cervera (Universidad de Cádiz, Spain) read an early version of this manuscript and made many helpful suggestions and comments. To all we are grateful.

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# A NEW SPECIES OF *LUCINOMA* (BIVALVIA: LUCINOIDEA) FROM A METHANE GAS SEEP OFF THE SOUTHWEST COAST OF CHILE

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*Abstract* A new species of *Lucinoma* is described from a previously unknown methane seep off Concepción, southern Chilean coast. Comparisons have been made with all known *Lucinoma* species, especially *L. lamellata* (= *L. antarctica*?), *L. galathea*, *L. annulata*, *L. aequizonatus* and *L. heroica*. Many of the new specimens are gerontic individuals—perceived as having slower or irregular growth, resulting in uneven shell thickening, height to length ratio reversal and sculptural irregularity.

*Key words* *Lucinoma*, Chile, methane seep.

## INTRODUCTION

An extensive gas hydrate field was recently reported by Morales (2003), between 35°S and 45°S off Chile. In turn, a methane seep area has been discovered off Concepción, Chile (36°S 73°W), which has yielded a fauna containing a number of chemosynthetic bivalve species (Sellanes *et al.*, 2004). Included were species of Vesicomidae (Sellanes & Krylova (2005), Thyasiridae (Oliver & Sellanes, in press), Lucinidae and Solemyidae. This paper describes the single species of lucinid collected, placing it in the genus *Lucinoma*.

The genus *Lucinoma* is widely distributed throughout the world's oceans and is now represented by nineteen described species, four of which have known associations with cold seeps (Oliver, in press).

A few species have been studied intensively in relation to their anatomy and symbiosis. These are *L. borealis* (Linnaeus, 1767) by Southward (1986) and Dando, Southward & Southward (1986); *L. aequizonata* (Stearns, 1890) & *L. annulata* (Reeve, 1850) by Distel & Felbeck (1987); *L. kazani* Salas & Woodside (2002) and *L. sp. nov.* Oliver (in press). The Chilean material consists of shells only and a similar study cannot, unfortunately, be done at this time. Focus is placed on comparisons with other East Pacific and Southern Ocean species of which there are five: *L. lamellata* (= *antarctica*?) (Philippi, 1855); *L. galathea* Marwick, 1953; *L. annulata* (Reeve, 1850); *L. aequizonata* (Stearns, 1890) and *L. heroica* Dall, 1901.

## Abbreviations used

BM(NH) British Museum of Natural History  
DMWNZ Dominion Museum Wellington New Zealand  
MNHNCL Museo Nacional de Historia Natural de Chile  
NMS National Museum of Scotland, Edinburgh  
NMW National Museum of Wales, Cardiff  
SBMNH Santa Barbara Museum of Natural History

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Fig. 1 Localities of material examined and 3 other known sites of *Lucinoma lamellata*.

SYSTEMATICS

Lucinoidea  
Lucinidae

Genus *Lucinoma* Dall, 1901  
Type species: *Lucina filosa* Stimpson, 1851

*Definition* (From Oliver, in press) Shell equivalve, equilateral, subcircular and lenticular. Lunule elongate, slightly sunken. Escutcheon long and narrow sometimes sunken. Sculpture concentric of low lamellae with raised lines between. Ligament deeply inset on nymph, sometimes below level of escutcheon sometimes slightly raised. Hinge teeth of 2 cardinals in each valve, 2a and 3b slightly bifid; anterior laterals (often obscure) in all, obscure posterior laterals in some. Anterior adductor scar long and divergent. Anatomy, mantle edge and mantle without accessory gill structures; exhalant siphon simple with few small papillae; ctenidium thick fleshy with muscular inter filamentar and inter lamellar junctions. Labial palps small sorting ridges few or lacking.

*Lucinoma anemiophila* n.sp.  
Figs 2-6

*Holotype* A complete shell, Station AGT 10, 40 nautical miles north-west off the Bay of Concepción, south-central Chile; 36°22.15' S, 73°42.85'W; 780m depth, MNHNCL201649.

*Paratypes* All as type locality: 1 complete shell, MNHNCL201650 + 3 valves, MNHNCL201651; 1 complete shell + 1 1\2 shell, NMW.Z.2005.004.0001.

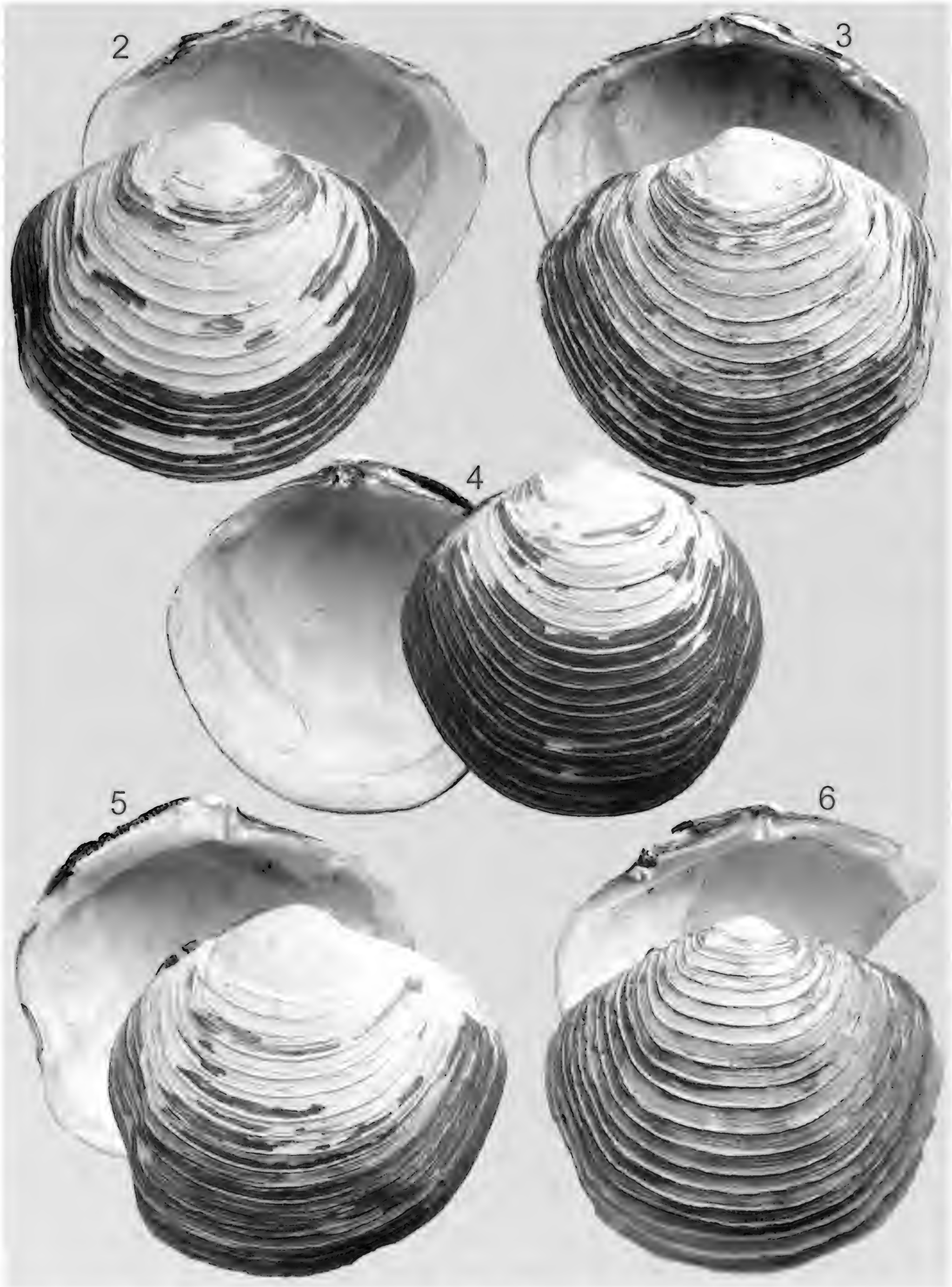
*Type Locality* Station AGT 10, 40 nautical miles north-west off the Bay of Concepción, south-central Chile; 36°22.15' S, 73°42.85'W; 780m depth

*Measurements* of shells from type material (see Table 1)

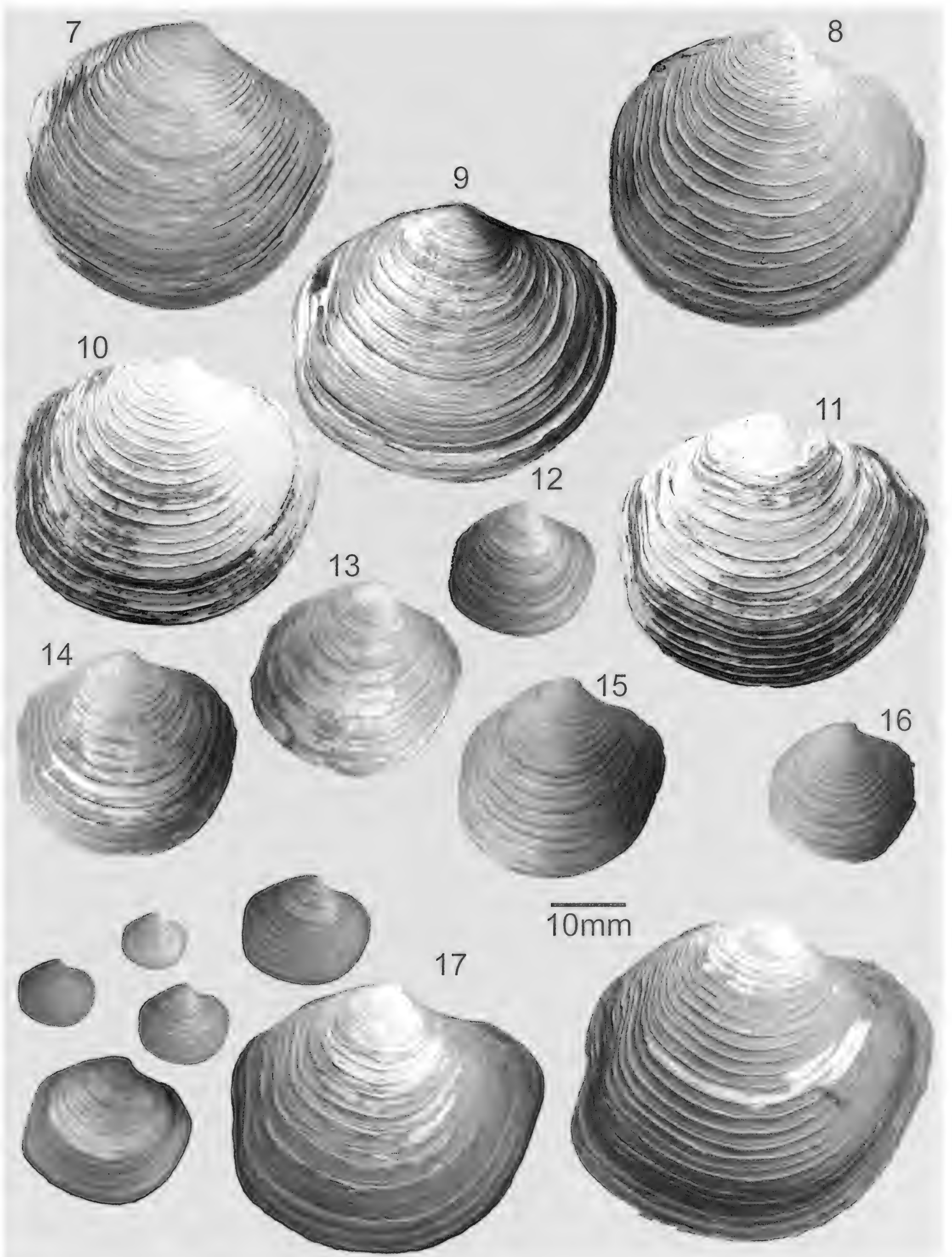
TABLE 1  
Measurements of type material

	Length mm	Height mm	Tumidity mm	Anterior scar Length mm	AA Scar angle	Escutcheon Length mm	Lunule Length mm
Holotype	61	54	29	24.7	23°	29.4	17.6
Paratype 1	55.5	56	34	25.0	18°	29.6	16.6
Paratype 2	44	41	26.5	20.1	22°	20.8	11.1
Paratype 3 (broken)	44.5	40	21	18.6	25°	20.1	9.5
Paratype 4	60.0	56.1	36.4	25.4	24°	26.6	17.3
Paratype 5	53.4	49.4	29.4	23.4	23°	23.4	13.9
Paratype 6	51.5	48.9	30.4	19.9	24°	23.6	14.4





**Figs 2-6** *Lucinoma anemiophila* 2-3 holotype (MNHNCL201649) 4-6 paratypes (MNHNCL201650, MNHNCL201651; NMW.Z.2005.004.0001).



**Fig. 7** *L. heroica* (SBMNH 34064) syntype, Baja California, 70mm **Fig. 8** *L. galathea* (MNZ M.064713) southern New Zealand, 39mm **Fig. 9** *L. aequizonata* (SBMNH 34079) syntype, Santa Barbara channel, 49mm **Fig. 10** *L. annulata* NMW.Z.1955.158, 56mm **Fig. 11** *L. anemiophila* (MNHNCL201649) holotype, off Concepcion, Chile, 61mm **Figs 12-17** *Lucinoma lamellata* all western Chile **12-14** Soot-Ryen (SMNH-74824) **15-16** Eltanin (DMWNZ M21560) **17** Osorio size series. Figs 12-17 Scale bar = 10mm.



## DESCRIPTION

The material at hand shows distinct variations between shells and consequently this description is for the holotype (Figs 2-3) only with the variations described subsequently. For measurements of type material see Table 1.

Shell 61mm in length, equivalve, almost equilateral, a little inflated (length to tumidity ratio = 2.1). Subcircular, longer than high, (length to height ratio = 1.13).

Lunule is long (length to lunule ratio = 3.47) and not sunken; lunule margin sloping gently and forming an angle with the short, straight but oblique anterior dorsal margin (anterior inhalant siphonal margin). Junction of anterior dorsal margin and ventral margin also angulate and the latter broadly curved; posterior margin truncate, slightly indented; posterior dorsal margin (= escutcheon margin) almost straight, long (length to escutcheon length ratio = 2.07) and sloping gently. Dorsal anterior margin long and angular, ventral anterior margin rounded down to ventral margin which is broadly curved. Ventral posterior margin broadly rounded, becoming truncate.

Concentric sculpture of widely-spaced, regular, raised, but flattened lamellae interspersed by 7-10 thin concentric lines. The lamellae are closer together on the subtruncate posterior margin. Shell colour cream with a greenish-brown periostracum.

Ligament long, deep and external. Two cardinals in each valve (2a, 2b + 3a, 3b). 2a + 3b bifid. Very small anterior lateral in rv and a hint of a socket in lv. Posterior laterals absent. Muscle scars are prominent; posterior scar is set against the pallial line and is approximate oval. Anterior scar is long (length to scar length = 2.47), free for 82% of length, diverging from pallial line at an angle of 23°. Anterior pedal retractor tiny, set just above adductor scar.

Paratype with a broken valve (Fig. 6) resembles the holotype. Other shells (Figs 4-6) have a different aspect in being heavier with deeply impressed muscle scars, an irregular surface and in outline the height equalling or exceeding the length (length to height ratio 0.99 to 1.08). The dorsal margins are less pronounced and overall there is a more rounded appearance. These shells are not necessarily large and the form is probably related to age and rate of growth. The irregular surface may indicate periods of very slow growth and in all, these shells may denote periodicity in the availability of sulphur or methane.

*Geographic Range* Known only from type locality.

*Biotope* Sticky dark grey mud smelling of sulphide. Carbonate crusts are also typical features of the area and gas hydrates were retrieved from subsurface sediments at a nearby site.

*Derivation of name* *anemiophila*, from the Latin *anemia*: flatulency and *phila*: lover of, referring to the gassy environment of the methane seepage area.

## COMPARISONS

Two species of *Lucinoma* have been previously reported from Chilean waters, namely *L. aequizonata* (Stearns, 1891) (Fig. 9) (see below) and *L. lamellata* (Smith, 1881) (Figs 12-17)—see the map (Fig. 1).

There has been uncertainty over the nomenclature of *L. lamellata*, some authors adopting *L. lamellata* (Smith, 1881) eg. Lamy, 1920; Soot-Ryen, 1959; Osorio & Reid, 2004 and SOMBASE (2005) while others consider *L. antarctica* (Philippi, 1855) to be a senior synonym eg. Bernard, 1983 and Forcelli, 2000. Most authors agree, as do we, that



Philippi's description is inadequate to recognise his species and the lack of illustrations and type material make this taxon indeterminate.

We have attempted to examine material relevant to these previous publications and have succeeded in comparing the shells cited by Smith, 1881 & 1885; Soot-Ryen, 1959; Osorio & Reid, 2004; Melvill & Standen, 1912. We have also examined material identified by RK Dell as *L. lamellata* from the collections made by the USNS *Eltanin* (Dell, 1990). The type material of *Diplodonta lamellata* Smith, 1881, 3 syntypes (BM(NH) 1879.10.15.65-66) from the south west coast of Chile represents the juvenile stages which can be recognised from the umbonal region of adult material also identified by Smith but coming from the Straits of Magellan. These shells characterise *L. lamellata* in having a subacute anterior margin, long sloping posterior margin, pointed beaks and a thick and moderately inflated shell. This form is also typical of the *Eltanin* material (Figs 15-16), which was also collected off the southwest coast of Chile.

However, some of the shells cited by Soot-Ryen (1959) (Fig. 14) and Osorio & Reid (2004) did not correspond well with typical *L. lamellata* in that they are more compressed, have a more rounded outline and are thinner shelled. Examination of all of Osorio's *L. lamellata* material collected in 2001 (site 4 on map) & 2002 (site 3 on map) allowed a complete growth series to be analysed (Fig. 17). It can be concluded that shells are initially rounded, thin, and compressed but as the animal grows, the shell becomes angular, thicker and more tumid. The rate of growth, however, is highly variable and consequently direct comparison of shells of similar sizes from different collection sites is not always possible. These differences are shown in Figs 12-17, especially on comparison of similar sized material: the Soot-Ryen material is typically posteriorly angular; *Eltanin* material has a long sloping posterior margin; and Osorio's material is almost truncated posteriorly.

Comparison of all *L. lamellata* material with the deep water seep material (Figs 11 & 12-17) suggests very strongly that they are not conspecific in that *lamellata* does not have an angulate anterior margin, truncated posterior margin, low, rounded beaks and a length/height ratio higher than 1.10. Dentition and muscle scars unfortunately cannot be used for identification purposes as all *Lucinoma* carry the same shape adductor scars and cardinals and lateral formations are also very similar. Dentition also changes with age so direct comparisons are only feasible with individuals of a similar age.

Just one record of *L. aequizonata* (Fig. 9) – possibly erroneous – places it in Chilean waters and gives the locality as 'Santa Barbara to south latitude 38° (Chile)' (Dall, 1921). *L. aequizonata* has an affinity with the seep specimens in the almost straight dorsal posterior margin and truncate posterior margin, although the dorsal anterior margin is long and straight and the anterior margin narrowly rounded to give a rectangular shape. The sculpture has more widely spaced concentric lamellae.

Comparison is also made with the only other southern ocean species, the New Zealand *L. galathea* (Fig. 8) Marwick, 1953. *L. galathea* is known from the Chatham Islands, south of New Zealand (Powell, 1979), has an almost circular outline, a straightened posterior margin, broadly rounded anterior margin and a widely spaced lamellar sculpture.

Three *Lucinoma* species are known from the eastern Pacific. *L. annulata* (Reeve, 1850), *L. heroica* (Dall, 1901) and *L. aequizonata* (Stearns, 1890) are all found northwards of Mexico (except the one Dall (1921) record of *L. aequizonata*). *L. annulata* (Fig. 10) is a common species and rather widespread; found from Alaska to southern California (Tucker Abbott, 1991; Coan, Scott & Bernard, 2000). Its southern limit is the Gulf of California (Keen, 1971). *L. annulata* has sharp, concentric lamellae and is very rounded unlike our truncated specimen. Only one record exists of *L. heroica* (Fig. 7), discovered in the Gulf of California at 1,836m (Dall, 1901). *L. heroica* has a more pointed umbo, is flexed posteriorly, anterior is much more narrowly rounded and is markedly more compressed.

Given the differences in shell morphology and despite the variation seen in the Chilean shells there is sufficient data to conclude that the creation of a new species is warranted. This is further supported by the unique habitat of *L. anemiophila* (Fig. 12), which appears to be restricted to a cold seep.

### ACKNOWLEDGEMENTS

Thanks to the BMNH for their photographs of *L. lamellata* and allowing us to view the type material; Santa Barbara Museum of Natural History for the images of *L. aequizonata* and *L. heroica*. For their loan material thanks to: Swedish Museum of Natural History, Stockholm (Soot-Ryen's Lund University Chile Expedition 1948-49 material); National Museum of Scotland, Edinburgh (W.S.Bruce Collection, Scottish National Antarctic Expedition 1902-1904); Dominion Museum Wellington New Zealand (USNS *Eltanin* material) and Cecilia Osorio.(Universidad de Chile, Santiago). Our thanks also to the officers and crew of R/V Vidal Gormáz, for their skilful assistance at sea. In addition, we are grateful to the Co-chief scientists of the cruise, Dr Richard Coffin and Dr Juan Díaz-Naveas, and the remaining scientific party, especially Dr Eduardo Quiroga. Funding for ship time was provided by the Office of Naval Research. Partial support for this research was provided by the Center for Oceanographic Research in the Eastern South Pacific (COPAS).

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# HABITAT REQUIREMENTS AND DISTRIBUTION OF *VERTIGO GEYERI* (GASTROPODA: PULMONATA) IN WESTERN CARPATHIAN RICH FENS

MICHAL HORSÁK<sup>1</sup> & MICHAL HÁJEK<sup>2</sup>

**Abstract** In the course of research concerning 123 Western Carpathian fens carried out between 1997 and 2003, *Vertigo geyeri* Lindholm, 1925 was found in 20 sites (including the first reliable record from Poland). *V. geyeri* occurs in the three structural-distinct types of fens. These types differ in their chemistry (mainly pH). Population density of *V. geyeri* significantly increases with increasing water pH ( $P < 0.003$ ). On the contrary, relationship between population density of target species and water conductivity significantly fits to the unimodal shape of the species response curve with the species optimum at about  $360 \mu\text{S}\cdot\text{cm}^{-1}$  ( $P < 0.001$ ).

The species occurrence in petrifying springs is restricted only to one vegetation-type: the Inner-Carpathian extremely rich fens of the *Caricetum davallianae* association. The rich peat-forming fen with scarce carbonate grains and presence of meadow species (*Valeriano simplicifoliae*-*Caricetum flavae*) is the second vegetation type, in which *V. geyeri* occurs in the same frequency but with lower abundance.

**Key words** *Vertigo geyeri*, Gastropoda, Slovakia, Poland, Present distribution, Habitat preferences, Ecology.

## INTRODUCTION

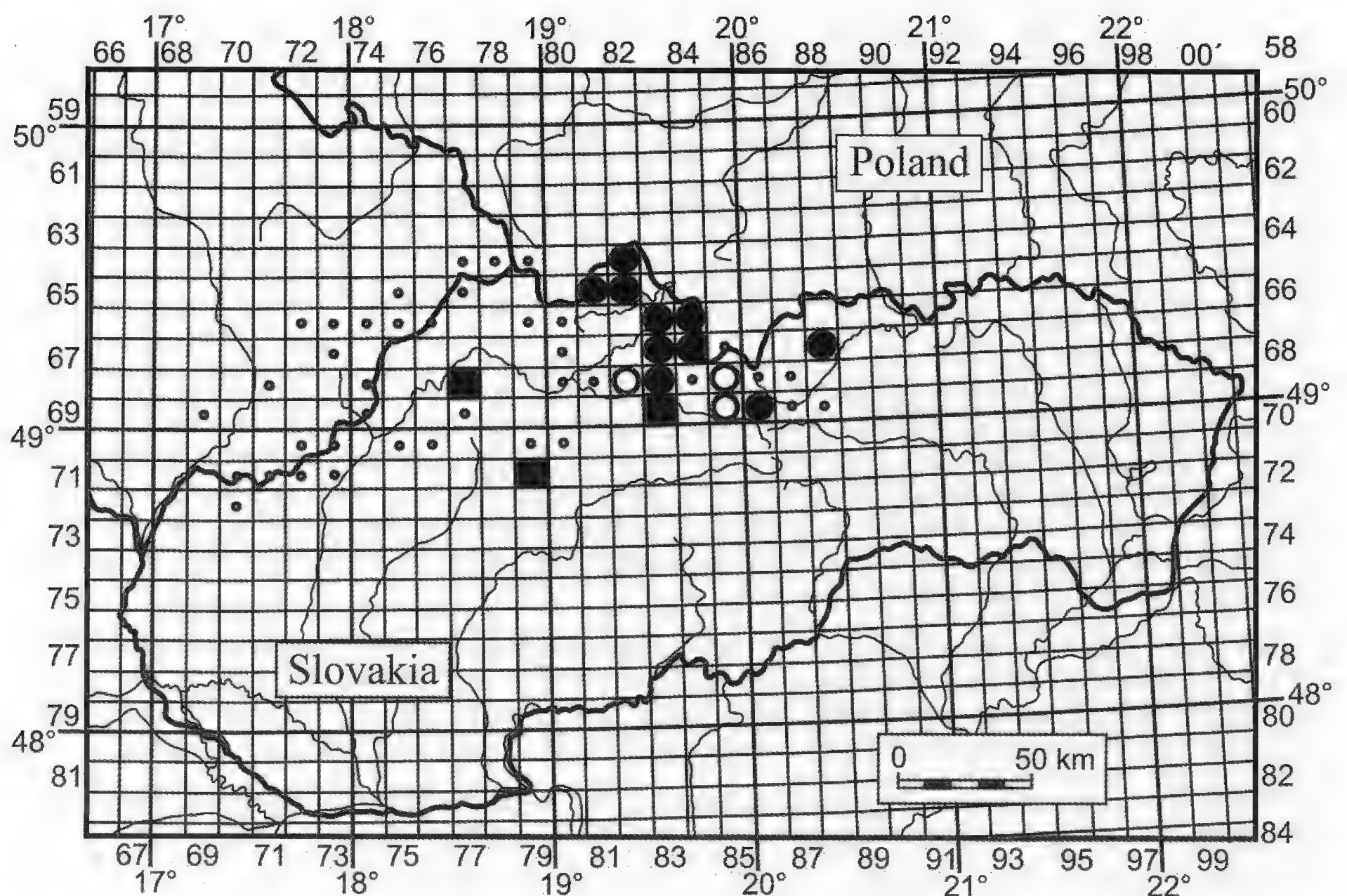
Four snails of genus *Vertigo*, namely *V. angustior*, *V. genesii*, *V. geyeri* and *V. moulinsiana* belong among the threatened animals listed in Annex II of the European Union Habitats and Species Directive (EUHSD). As a result of a workshop on the conservation biology of *Vertigo* species, the data relevant to the conservation of the four target *Vertigo* species were brought together as much as possible (Speight, *et al.* 2003). However, no concrete data from Western Carpathians, where these species are locally still common, were published there.

*V. geyeri* is a boreo-alpine species, which is present in the Boreal, Alpine, Continental and Atlantic zones of the Europe (Falkner, *et al.* 2001). Up to now, the knowledge about Western Carpathian distribution of the species was limited to seven Slovak sites (Ložek, 1971; Kroupová, 1986; Lisický, 1991). In all cases they were calcareous spring fens of the *Caricetum davallianae* vegetation with calcium carbonate precipitation. *V. geyeri* was therefore considered a typical inhabitant of petrifying spring fens (Ložek, 1992; Šteffek, 1994).

*V. geyeri* was also reported by Piechocki (1974) from central Poland (Świętokrzyskie Mts), but the record was based on atypical specimens of *Vertigo alpestris* (Pokryszko, 1990). Geyer (1919) mentioned *V. geyeri* from the vicinity of Białowieża, from the area which is a part of Belarus at present. Dyduch (1980) recorded *Vertigo genesii* from the Polish part of the Białowieża Forest. She did not mention any characters and provided no figure; her specimens (1 juvenile and 3 adult shells) were subsequently lost and could not be re-examined. Since for a long time *V. geyeri* was regarded as a subspecies of *V. genesii*, her record could pertain to either species. The repeated efforts of B. Pokryszko to find *V. geyeri* (of *genesii*), or at least a favourable habitat in the Polish part of Białowieża failed completely (Pokryszko, 1998). She even assumes that Geyer misidentified his material.

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**Figure 1** Position of the sampling sites projected onto mapping grid system with present known distribution of *Vertigo geyeri* Lindholm, 1925 in the Western Carpathians. New records (big points), old records (circles), both old and new records (squares), sites with no record of *V. geyeri* (small points).

Similarly, B. Pokryszko looked for *V. geyeri* in the Polish part of the Tatra Mts. inspired by Kroupova's (1986) record from Slovakia (former Czechoslovakia). She found suitable habitats but not the snail.

This species is a typical inhabitant of open alkaline fens with high and stable groundwater level, but often of limited area (a few m<sup>2</sup>). Considering the poor-rich mineral gradient, this snail can live not only in extremely rich fens, but also in moderately rich fens with occurrence of calcitolerant peat mosses (rich *Sphagnum*-fens according to Horsák and Hájek, 2003). In Finland and Russian Karelia *V. geyeri* has also been found in wet open deciduous forest (Valovirta, 2003).

The objective of this paper is to bring new knowledge on the distribution and habitat preferences of *V. geyeri* from Western Carpathians, and to describe its molluscan and vegetational associations. Our previous investigation of biological diversity of Western Carpathian fens revealed a strong ability of vegetation data to predict the composition and diversity of snail communities (Horsák and Hájek, 2003). Therefore, the population density of the target species was studied in relation not only to base status of fen, but also to the vegetation composition.

## MATERIAL AND METHODS

### HABITAT NOMENCLATURE

In order to express the environmental differences among studied habitats clearly, we classified sample plots (i) a priori with respect to structural attributes connected with major gradient in water chemistry and directly influencing the mollusc communities (Horsák and Hájek, 2003) and (ii) numerically according to total species composition of

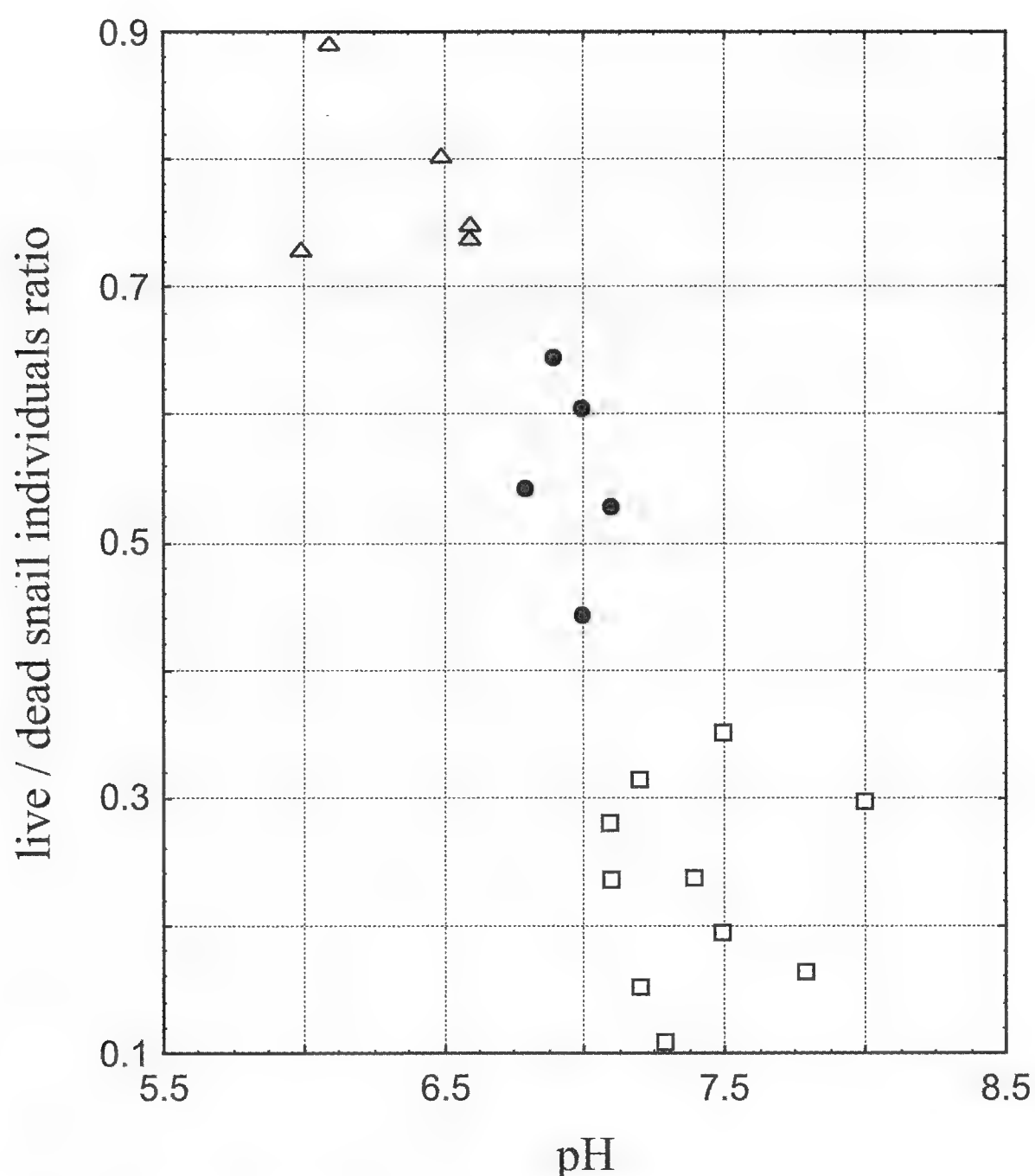




Figure 2 Pastierske II (Loc. no. 10) - an extremely rich fen with rich population of *Vertigo geyeri*



Figure 3 Demänovská valley (Loc. no. 6) - a brown-moss rich fen with rich population of *Vertigo geyeri*



**Figure 4** Ratio of live and dead individuals of all snails collected in the sites with occurrence of *Vertigo geyeri* in relation to water pH. Explanation of symbols used: squares - rich fens with tufa formation (10 sites), points - brown-moss rich fens without tufa formation (5 sites), triangles - rich *Sphagnum*-fens with occurrence of calcitolerant *Sphagnum* species (5 sites).

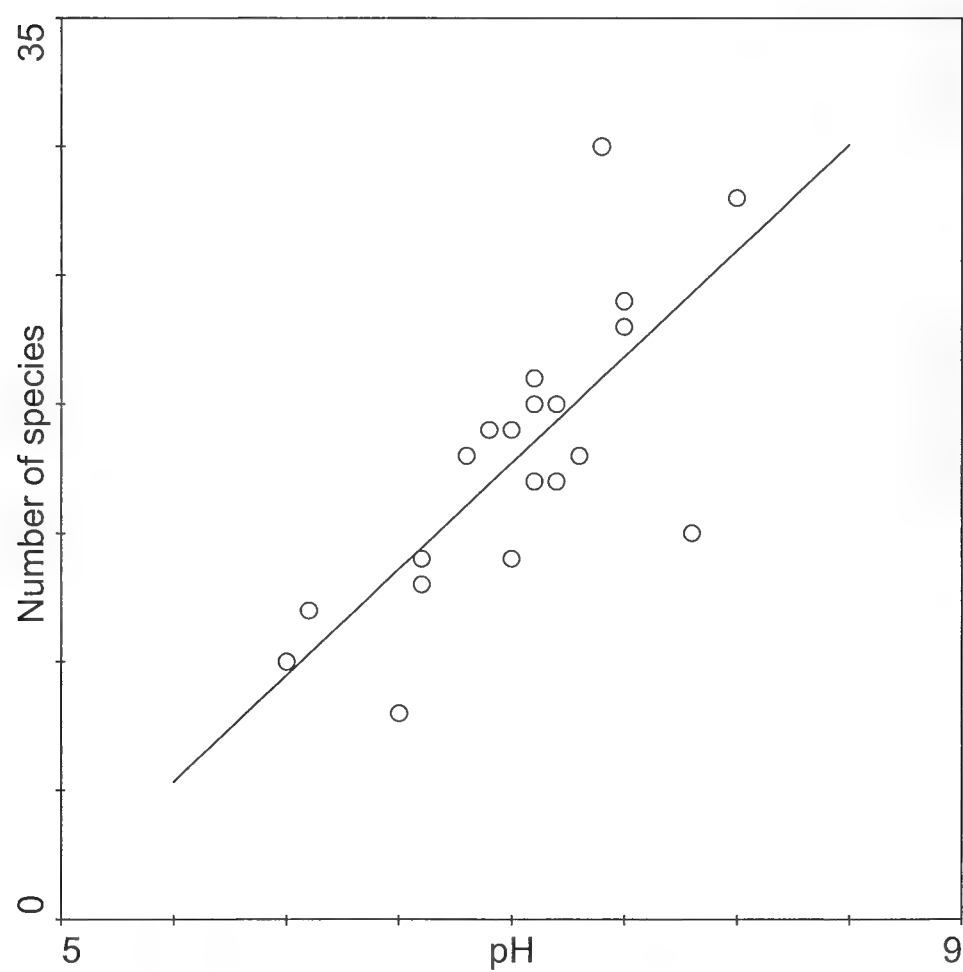
the vegetation. Vegetation clusters obtained in numerical classification were identified in term of phytosociological units. Table 1 summarises the nomenclature of all structural and vegetational habitat types.

#### FIELD SAMPLING

Field work was conducted from 1997 to 2003. Altogether 123 sites were studied. The majority of these sites was situated in the Czech Republic (40) and Slovakia (81), only two sites were in Poland (Fig. 1).

In each site, one sample of 12 litres volume comprising the upper soil layer including litter and herbaceous vegetation was collected. The method of sample processing (called wet washing) is described in details by Horsák (2003). Samples were not collected randomly, as the material collected was meant to reflect the same vegetation composition and structure as the vegetation relevé. The primary goal was always to detect the site's species as exhaustively as possible. Abundance was calculated from live specimens and empty shells with entire periostracum. The mollusc species names are given according to Juříčková, *et al.* (2001), excluding *Euconulus alderi* (Gray, 1840). Its actual name *E. praticola* (Reinhartd, 1883) is used (Falkner, *et al.* 2002).

In all sites, the occurrence and cover of plant species were recorded on the nine-grade Braun-Blanquet scale (van der Maarel, 1979) for both vascular plants and bryophytes. Only one relevé per spring fen was analysed. The malacological litter samples were taken in the vegetation relevé plots (ca 16 m<sup>2</sup> each). The names of the plant communities are given according to Stanová and Valachovič (2002), vascular plants and bryophytes according to Marhold (1998) and Kučera and Váňa (2003).



**Figure 5** Number of species in relation to water pH in sites with occurrence of *Vertigo geyeri*. The curve is fitted by linear regression ( $P < 0.0001$ ).

Water conductivity and pH were measured in the micro-sites best supplied by water in the central parts of the springs, using portable instruments with automatic temperature compensation (CM 101 and PH 119, Snail Instruments). The readings were standardized to 20 °C. Conductivity caused by  $H^+$  ions in acid waters was subtracted (Sjörs, 1952). These two environmental variables are rather easily measured, explain a great part of fen vegetation variability and are relatively highly temporally stable, what allow to directly compare data measured at other sites and times (Hájek and Hekera, 2004).

DATA PROCESSING

For the compilation of figure 1, the records of *V. geyeri* adopted from Ložek (1971), Kroupová (1986), and Lisický (1991) have been used.

All our original data from 123 sites was divided into three separate data-sets,

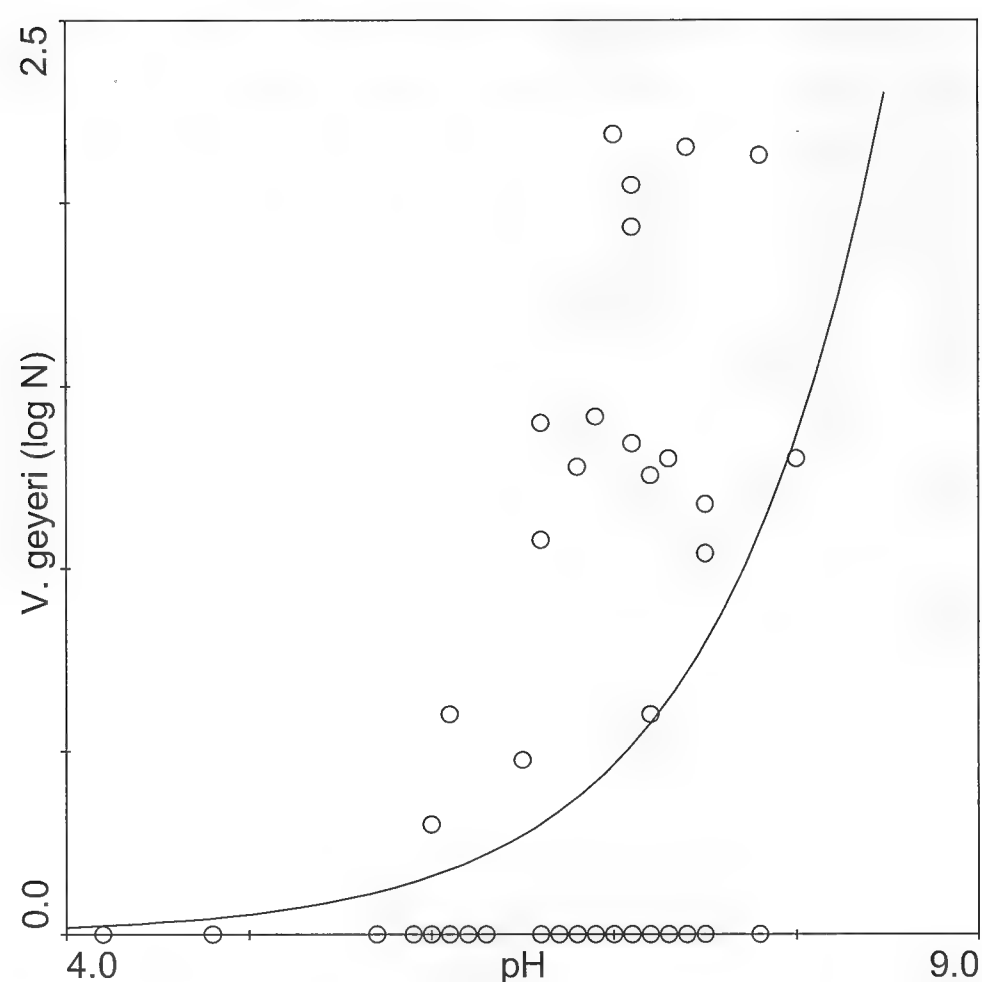
which were used for different statistical treatments. The first file includes 20 sites with occurrence of target species. The results obtained from this file are presented in Fig. 1, 4, 5 and Tab. 2, 3. The second file consists of 55 sites that are situated within the known

TABLE 1

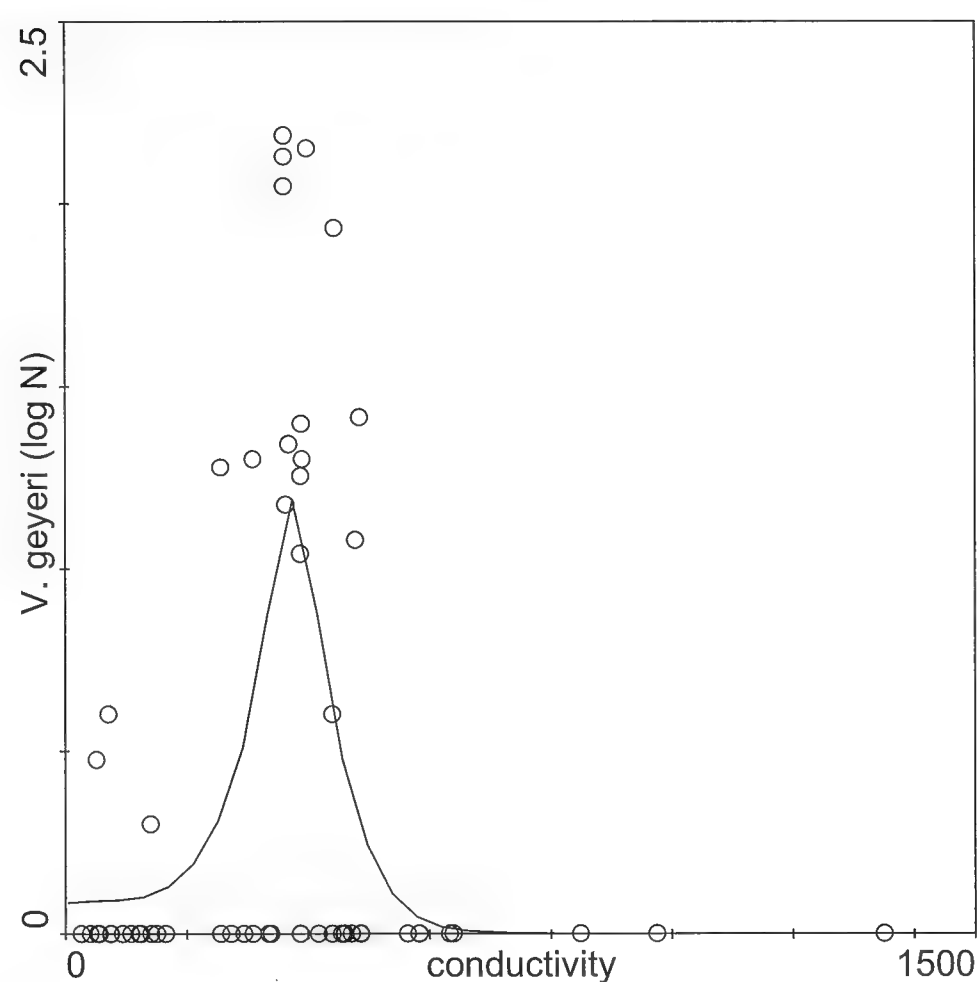
Habitat classification and nomenclature based on structural and vegetation data

Structural habitat type (Horsák and Hájek 2003)	Vegetation types obtained by TWINSpan
Extremely rich fens with tufa formation (petrifying springs)	Group 1.1: Inner-Carpathian travertine swards ( <i>Glauco-Trichophoretum pumili</i> )
	Group 1.2: Inner-Carpathian extremely rich fens ( <i>Caricetum davallianae</i> )
	Group 2.2: Outer-Carpathian extremely rich tufa- forming fens ( <i>Carici flavae-Cratoneuretum</i> )
Brown-moss rich fens without tufa formation	Group 2.1: Rich peat-forming fens with scarce carbonate grains and presence of meadow species ( <i>Valeriano simplicifoliae-Caricetum flavae</i> ) and succes- sionally advanced stages with calcitolerant <i>Sphagna</i>
Rich <i>Sphagnum</i> -fens with the occurrence of calcitolerant <i>Sphagnum</i> species	
Poor acidic fens	Not included in TWINSpan





**Figure 6** Abundance of *Vertigo geyeri* (in log scale) in relation to water pH in all sites sampled within the area of known distribution in the Western Carpathians. Species response curve is fitted with generalized additive model (GAM) with one degree of freedom ( $P = 0.0025$ ).



**Figure 7** Abundance of *Vertigo geyeri* (in log scale) in relation to water conductivity ( $\mu\text{S}\cdot\text{cm}^{-1}$ ; 20 °C) in all sites sampled within the area of known distribution in the Western Carpathians. Species response curve is fitted with generalized additive model (GAM) with four degrees of freedom ( $P < 0.00001$ ).

distribution range of *V. geyeri* in Western Carpathians. These sites cover the entire gradient from mineral-poor acidic to mineral-rich alkaline sites in order to show the response of the species to measured hydrochemical factors (Fig. 6, 7). In contrast, 81 sites included in the third file are spaced throughout the whole study area in order to describe habitat preferences of target species across a wide territory from Outer to Inner Carpathians. This third file covers such parts of the major hydrochemical gradient that match with ecological requirements of *V. geyeri*; the most acidic sites have been excluded. The third file was also used for analysis of vegetation and for studying relationships between target species and vegetation associations (Fig. 8, 9; Tab. 4).

The CANOCO 4.5 package was used for multivariate analyses (ter Braak and Šmilauer, 2002). Vegetation data have been subjected to detrended correspondence analysis (DCA). Environmental variables have been projected a posteriori onto the resulting biplot. The sites with the occurrence of *V. geyeri* were highlighted by a different symbol of various sizes which depended on species abundance in site. Generalized additive models (Hastie and Tibshirani, 1990; Lepš and Šmilauer, 2003) have been used to describe the response of target species to environmental gradients.

Vegetation was classified to four major types using TWINSpan. The character species for each vegetation type were selected according to their fidelity (Chytrý, et al. 2002) using JUICE software (Tichý, 2002). Mean abundance of *V. geyeri* was calculated for each cluster.

## RESULTS

From all studied sites, *V. geyeri* was found in 19 sites in NE Slovakia and one site in adjacent part of Poland. The majority of those finds are new (cf. Fig. 1). The discovery

of frequent occurrence in Orava Region (Slovakia) with overlap to Poland is of prime importance as this is the first reliable record from Poland. Two studied sites with rich population of *V. geyeri* are shown in Figs 2 and 3.

All species found in the particular sites with their dominance are given in the Tab. 2. Fifty-two species (9 aquatic) were encountered in the sites with *V. geyeri*. Numbers of *V. geyeri* individuals per sample varied from 153 to 1 with dominance between 36 % and 0.4 %. Species richness ranged from 30 (incl. 7 aquatic) to 8 (incl. 2 aquatic) species and numbers of specimens from 1976 (784 aquatic) to 52 (2 aquatic) individuals per sample. Eighteen species were common (constancy >40 %), fourteen rather common (20-40 %) and eighteen rare (<10 %) (for concrete species see Tab. 2). The land snails which reached the highest average dominance were *Carychium minimum*, *Oxyloma elegans*, *Vertigo geyeri*, *V. antivertigo*, *Vallonia pulchella* and *Vertigo substriata*.

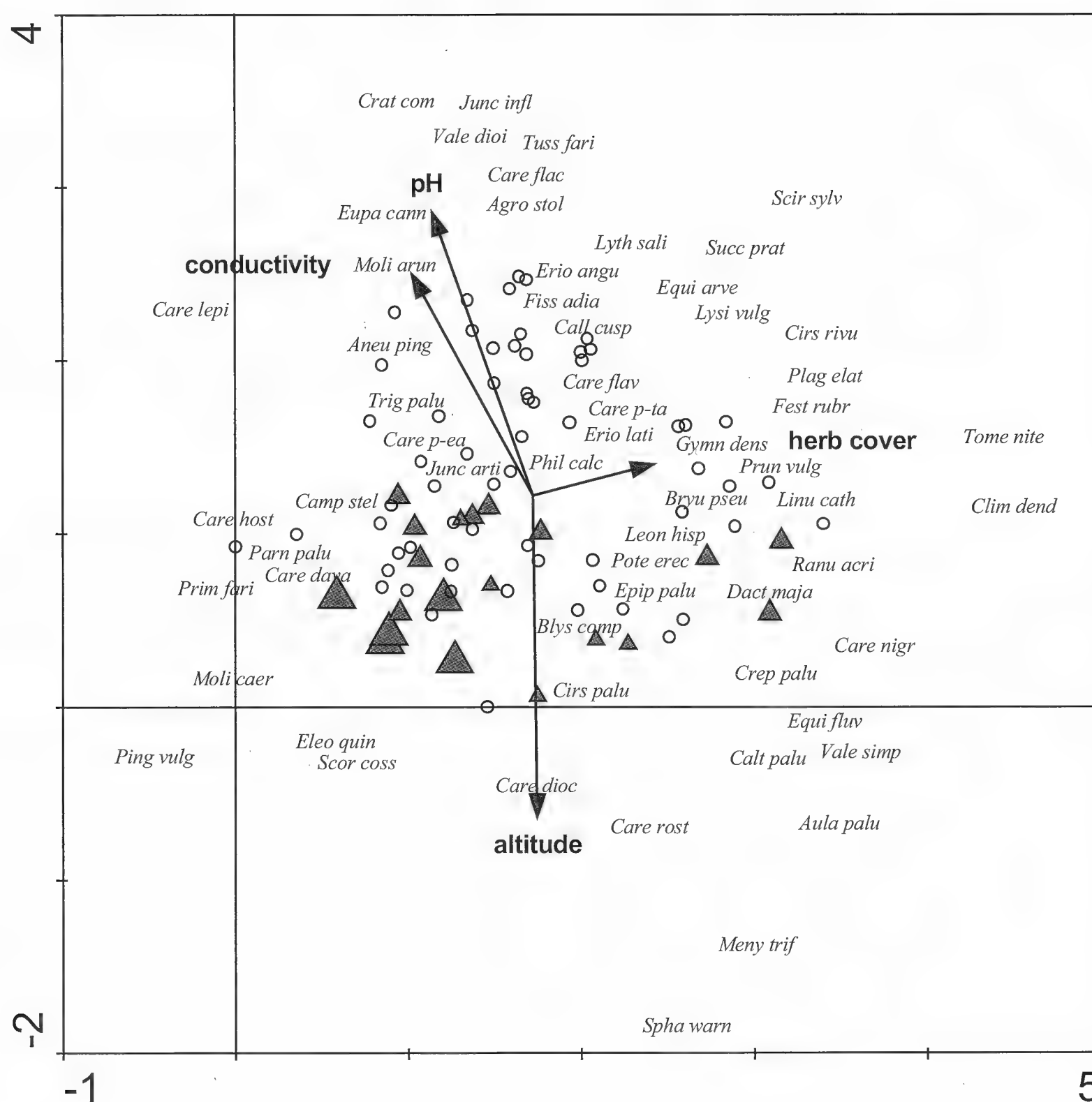
TYPE OF FEN AND CHEMICAL FACTORS RELATED TO ABUNDANCE OF *VERTIGO GEYERI*  
*V. geyeri* was found in the three distinct types of fens. These types differ in their chemistry (mainly pH, see Tab. 3) and vegetation. Chemical differences are also reflected in higher ratio of live and dead snail individuals towards to acidic sites (Fig. 4). Number of species is strongly correlated with water pH (Fig. 5).

The first type includes extremely rich fens with tufa formation, called petrifying springs (10 sites). The median species richness was 21 (ranged from 15 to 30) mollusc species. Mollusc communities were very rich, with nineteen species found exclusively on this type of fen. Among these molluscs are also rare and endangered snail species (e.g. *Pupilla alpicola*, *Cochlicopa nitens*). Number of individuals of *V. geyeri* varied from 3 to 141 (mean 46). The second type consists of brown-moss rich fens without tufa formation (5 sites). Species richness of mollusc assemblages was still rich, varied from 14 to 19 (median 18) species. Number of individuals of *V. geyeri* ranged from 1 to 153 (mean 62). Structure and species composition of these two types were very similar and they agreed in abundances of *V. geyeri* as well. Third type includes rich *Sphagnum*-fens with the occurrence of calcitolerant *Sphagnum* species (5 sites). Low supply of calcium caused lower species richness (from 8 to 14 species, median 12 spp.) in contrast to the types mentioned above. Populations of *V. geyeri* were also poorer, ranged from 1 to 24 (mean 8) specimens per sample.

Population density of *V. geyeri* increases significantly with increasing water pH (Fig. 6). On the contrary, different pattern within relationship between population density of *V. geyeri* and water conductivity were found (Fig. 7). There is the unimodal shape of the species response curve with the species optimum about  $360 \mu\text{S}\cdot\text{cm}^{-1}$  (20 °C). One of the most important ecological requirements for *V. geyeri* is high and stable ground-water level. This factor has strong influence on population density and even distribution on a site. In the drier sites the target snail reaches significantly low population density than it is in well-water soaked sites. There were no preferences for slope of different aspects.

#### VEGETATIONAL PREFERENCES OF *VERTIGO GEYERI*

The species occurrence in petrifying springs is restricted only to one vegetation-type: the Inner-Carpathian extremely rich fens of the *Caricetum davallianae* association (TWINSPAN group 1.2). This vegetation type is differentiated against other Carpathian rich fens mostly by presence of *Carex lepidocarpa*, *C. davalliana*, *Primula farinosa*, *Tofieldia calyculata*, and *Pinguicula vulgaris*. It develops on large submontane fens of stable water regime, rich in calcium, lacking peat mosses and depositing unconsolidated tufa or lacustrine chalk (Háberová and Hájek, 2001). No individual of *V. geyeri* were found in the other two types of petrifying springs, in Outer-Carpathian tufa-forming fens of the *Carici flavae-Cratoneuretum* association and in Inner-Carpathians travertine swards of the *Glauco-Trichophoretum pumili* association (Fig. 9, Tab. 4).

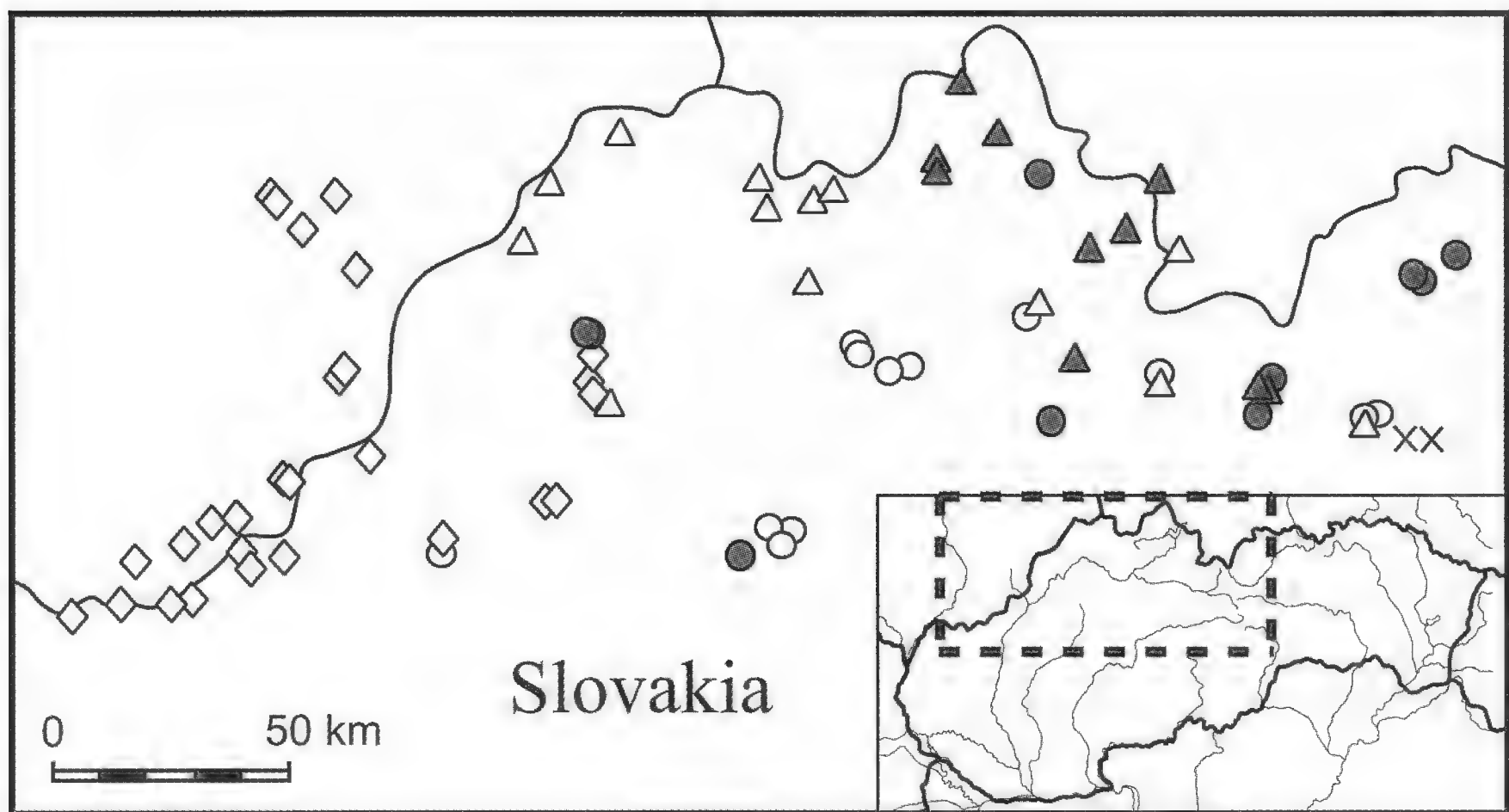


**Figure 8** Detrended correspondence analysis (DCA) of vegetation relevés. Graph shows position of all relevés (sites - as circles) along the first two ordination axes, the position of the most important species (weight > 2 %) and the environmental variables, which are projected onto resulting biplot. Triangles represent sites with occurrence of *Vertigo geyeri*, their size expresses a category of abundance per sample: small = 1-9, medium = 10-79, big = 80-160 specimens.

Species list: **Vascular plants** - *Agrostis stolonifera*, *Blysmus compressus*, *Caltha palustris* s.lat., *Carex davalliana*, *C. dioica*, *C. flacca*, *C. flava* s.str., *C. hostiana*, *C. lepidocarpa*, *C. nigra*, *C. panicea*, *C. paniculata*, *C. rostrata*, *Cirsium palustre*, *C. rivulare*, *Crepis paludosa*, *Dactylorhiza majalis*, *Equisetum arvense*, *E. fluviatile*, *Eleocharis quinqueflora*, *Epipactis palustris*, *Eriophorum angustifolium*, *E. latifolium*, *Eupatorium cannabinum*, *Festuca rubra*, *Gymnadenia densiflora*, *Juncus articulatus*, *J. inflexus*, *Leontodon hispidus*, *Linum catharticum*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Menyanthes trifoliata*, *Molinia arundinacea*, *M. caerulea*, *Parnassia palustris*, *Pinguicula vulgaris*, *Potentilla erecta*, *Primula farinosa*, *Prunella vulgaris*, *Ranunculus acris*, *Scirpus sylvaticus*, *Succissa pratensis*, *Triglochin palustre*, *Tussilago farfara*, *Valeriana dioica*, *V. simplicifolia*; **Bryophytes** - *Aneura pinguis*, *Aulacomnium palustre*, *Bryum pseudotriquetrum*, *Calliergonella cuspidata*, *Campylium stellatum*, *Climacium dendroides*, *Fissidens adianthoides*, *Palustriella commutata* (Syn. *Cratoneuron commutatum*), *Philonotis calcarea*, *Plagiomnium elatum*, *Scorpidium cossonii*, *Sphagnum warnstorffii*, *Tomenthypnum nitens*.

The second vegetation type, in which *V. geyeri* occurs in the same frequency, is the rich peat-forming fen with scarce carbonate grains and presence of meadow species (*Valeriano simplicifoliae*-*Caricetum flavae*, TWINSpan group 2.1) which was clustered with successional advanced stages with calcitolerant *Sphagnum* spp. in the TWINSpan analysis. When *V. geyeri* occurred in this advanced stage, it avoids *Sphagnum*-rich patches. The diagnostic species for this vegetation type are those, which avoid extremely alkaline





**Figure 9** The distribution of 81 studied fens in the Western Carpathians, classified by TWINSpan according to vegetation data. Full symbols represent the sites with the occurrence of *Vertigo geyeri*. Explanation of symbols: diamonds - group 2.2: *Carici flavae*-*Cratoneuretum*; circles - group 1.2: *Caricetum davallianae*; triangles - group 2.1: *Valeriano simplicifoliae*-*Caricetum flavae*; crosses - group 1.1: *Glauco-Trichophoretum pumili*. For further description of habitat types see Tab. 1, 4 and text.

sites (*Aulacomnium palustre*, *Agrostis canina*, *Philonotis fontana*), prefer fen habitats with high water level (*Calliergon giganteum*) or overlap to wet meadows (*Galium uliginosum*, *Valeriana simplicifolia*, *Crepis paludosa*, *Angelica sylvestris*). Due to less severe, albeit still nutrient-limiting environment all these species can co-exist forming the extraordinary plant species richness of this vegetation type (Hájková and Hájek, 2003b).

## DISCUSSION

Until now, *V. geyeri* has been known from Western Carpathians only from extremely rich fens with *Carex davalliana* and *Primula farinosa* (Ložek, 1992; Šteffek, 1994). The present investigation of all Carpathian fen vegetation, including sites relatively poor in carbonates, revealed presence of this species also in other habitat types that were generally overlooked by malacologists (Horsák and Hájek, 2003). As a boreo-alpine species, it is more or less continuously distributed in northern Europe, mainly in Norway and Sweden (von Proschwitz, 2003). In this area it occurs in fens only moderately rich in minerals, but in such cases it is always restricted to richer spots. The same situation was observed in Western Carpathians. On rich *Sphagnum*-fens with occurrence of calcitolerant *Sphagnum* species *V. geyeri* prefers mineral-rich patches which are still in a contact with mineral soil. These patches are more fed by mineral-rich groundwater than precipitation as adjacent parts.

The distribution pattern of *V. geyeri* in Western Carpathian rich fens coincides to that of some plants. Several rich fen species (*Primula farinosa*, *Carex dioica*, *C. hostiana*, *C. lepidocarpa* and *Pinguicula vulgaris*) display a nearly identical distribution range within the study area as *V. geyeri* does. By analogy to *V. geyeri*, they are absent in Inner-Carpathian mountain ranges composed of flysch bedrock, probably due to short time of fen vegetation existence elapsed in the Holocene (Hájková and Hájek, 2003a) and due to small areas of fens, which are exposed to strong edge effect (Hájková and Hájek, 2003b). These macroecological hypotheses can explain the absence of the target species in tufa-

TABLE 2

List of all mollusc species found in sites with occurrence of *Vertigo geyeri* (their dominance (%) is given). The number of each site corresponds to its number used in Appendix. Sites no. **1-10**: extremely rich fens with tufa formation (petrifying springs); no. **11-15**: brown-moss rich fens without tufa formation; no. **16-20**: rich *Sphagnum*-fens with the occurrence of calcitolerant *Sphagnum* species.

Terrestrial species	1	2	3	4	5	6	7	8	9	10
<i>Platyla polita</i> (Hartmann, 1840)	-	1.08	3.63	0.48	-	-	-	2.56	-	-
<i>Carychium minimum</i> Müll., 1774	10.32	34.77	31.04	42.00	28.85	19.24	-	12.82	15.42	2.68
<i>Carychium tridentatum</i> (Risso, 1826)	0.25	1.51	16.02	0.95	1.95	-	0.34	-	-	-
<i>Cochlicopa nitens</i> (Gallenstein, 1848)	2.68	-	-	-	-	-	-	-	-	-
<i>Cochlicopa lubrica</i> (Müll., 1774)	5.96	0.65	3.25	1.19	4.12	8.21	26.10	-	2.51	0.27
<i>Pupilla alpicola</i> (Charpentier, 1837)	13.34	-	-	-	-	0.98	-	3.42	10.05	-
<i>Vallonia enniensis</i> (Gredler, 1856)	0.08	-	-	-	-	-	-	-	-	-
<i>Vallonia pulchella</i> (Müll., 1774)	0.25	0.22	3.13	-	0.87	10.42	6.44	15.38	22.11	16.89
<i>Acanthinula aculeata</i> (Müll., 1774)	-	0.86	-	0.24	-	-	-	-	-	-
<i>Columella edentula</i> (Drap., 1805)	-	4.97	2.63	5.01	0.22	-	1.02	-	-	-
<i>Vertigo angustior</i> Jeffreys, 1830	6.46	9.29	5.38	6.92	13.67	0.25	-	1.71	11.56	0.27
<i>Vertigo antivertigo</i> (Drap., 1801)	2.27	0.22	7.01	5.97	24.51	-	-	-	21.61	-
<i>Vertigo geyeri</i> Lindholm, 1925	11.83	4.10	1.25	3.34	4.56	10.42	1.02	16.24	9.05	35.92
<i>Vertigo pygmaea</i> (Drap., 1801)	4.53	-	-	-	-	-	-	-	0.50	-
<i>Vertigo substriata</i> (Jeffreys, 1833)	2.10	3.89	3.63	6.68	3.90	-	1.69	-	-	-
<i>Clausilia pumila</i> C. Pfeiffer, 1828	-	-	-	-	-	-	-	1.71	-	-
<i>Alinda biplicata</i> (Montagu, 1803)	-	3.02	-	1.91	-	-	-	-	-	-
<i>Succinella oblonga</i> (Drap., 1801)	2.52	-	-	-	-	1.84	0.68	1.71	-	-
<i>Succinea putris</i> (L., 1758)	7.72	-	1.25	-	2.82	15.32	0.34	0.85	-	-
<i>Oxyloma elegans</i> (Risso, 1826)	14.09	6.48	5.76	0.95	-	10.66	17.97	16.24	11.06	26.81
<i>Punctum pygmaeum</i> (Drap., 1801)	2.01	1.30	5.63	0.72	1.08	0.12	4.41	3.42	-	1.07
<i>Zonitoides nitidus</i> (Müll., 1774)	4.36	-	-	-	2.17	2.45	-	-	2.01	-
<i>Euconulus praticola</i> (Reinhardt, 1883)	5.03	1.73	-	0.72	6.07	10.54	-	7.69	5.03	9.12
<i>Euconulus fulvus</i> (Müll., 1774)	-	10.37	6.38	5.73	0.87	-	7.46	-	-	-

TABLE 2 - continued

Terrestrial species	11	12	13	14	15	16	17	18	19	20
<i>Platyla polita</i> (Hartmann, 1840)	-	-	-	-	-	-	-	-	-	-
<i>Carychium minimum</i> Müll., 1774	48.84	-	39.63	27.55	13.83	44.58	26.88	27.78	63.64	48.00
<i>Carychium tridentatum</i> (Risso, 1826)	-	5.16	-	18.29	-	-	30.00	-	-	-
<i>Cochlicopa nitens</i> (Gallenstein, 1848)	-	-	-	-	-	-	-	-	-	-
<i>Cochlicopa lubrica</i> (Müll., 1774)	2.33	12.70	9.26	2.55	0.68	-	-	16.67	-	-
<i>Pupilla alpicola</i> (Charpentier, 1837)	-	-	-	-	-	-	-	-	-	-
<i>Vallonia enniensis</i> (Gredler, 1856)	-	-	-	-	-	-	-	-	-	-
<i>Vallonia pulchella</i> (Müll., 1774)	0.39	1.19	4.44	0.46	27.21	-	-	-	-	-
<i>Acanthinula aculeata</i> (Müll., 1774)	-	-	-	-	-	-	-	-	-	-
<i>Columella edentula</i> (Drap., 1805)	-	-	-	0.23	-	-	4.38	-	-	2.00
<i>Vertigo angustior</i> Jeffreys, 1830	3.10	6.35	18.15	-	2.72	-	-	-	-	-
<i>Vertigo antivertigo</i> (Drap., 1801)	11.63	5.95	6.30	-	-	26.51	1.25	8.33	9.09	-
<i>Vertigo geyeri</i> Lindholm, 1925	9.69	0.40	6.67	25.69	34.69	13.25	7.50	8.33	9.09	4.00
<i>Vertigo pygmaea</i> (Drap., 1801)	-	0.79	-	-	11.34	-	-	-	-	-
<i>Vertigo substriata</i> (Jeffreys, 1833)	1.55	1.59	0.74	4.63	-	3.61	22.50	11.11	18.18	30.00
<i>Clausilia pumila</i> C. Pfeiffer, 1828	-	-	-	-	-	-	-	-	-	-
<i>Alinda biplicata</i> (Montagu, 1803)	-	-	-	-	-	-	-	-	-	-
<i>Succinella oblonga</i> (Drap., 1801)	-	-	0.37	-	-	-	-	-	-	-
<i>Succinea putris</i> (L., 1758)	8.91	4.76	1.11	8.10	-	4.82	1.25	-	-	-
<i>Oxyloma elegans</i> (Risso, 1826)	7.36	-	3.70	-	-	-	-	-	-	-
<i>Punctum pygmaeum</i> (Drap., 1801)	0.39	1.98	1.11	0.46	0.45	2.41	-	-	-	-
<i>Zonitoides nitidus</i> (Müll., 1774)	-	-	-	-	-	-	-	-	-	-
<i>Euconulus praticola</i> (Reinhardt, 1883)	4.26	11.51	-	6.94	6.35	2.41	0.94	-	-	-
<i>Euconulus fulvus</i> (Müll., 1774)	-	-	3.70	-	-	-	-	-	-	14.00



TABLE 2 - continued

Terrestrial species	1	2	3	4	5	6	7	8	9	10
<i>Vitrina pellucida</i> (Müll., 1774)	0.34	-	0.13	-	0.43	-	-	-	-	-
<i>Semilimax semilimax</i> (J. Fér., 1802)	-	-	1.13	0.72	-	-	-	-	-	-
<i>Vitrea crystallina</i> (Müll., 1774)	-	1.73	-	-	-	-	6.10	-	-	-
<i>Vitrea diaphana</i> (Studer, 1820)	-	0.22	-	0.24	-	-	-	-	-	-
<i>Vitrea transsylvanica</i> (Clessin, 1877)	-	-	0.13	-	-	-	5.76	-	-	-
<i>Aegopinella minor</i> (Stabile, 1864)	-	-	-	-	-	-	0.34	-	-	-
<i>Aegopinella pura</i> (Alder, 1830)	-	0.22	0.75	1.19	-	-	1.02	-	-	-
<i>Perpolita hammonis</i> (Strórm, 1765)	1.59	2.81	1.25	-	-	4.90	17.29	12.82	-	6.70
<i>Perpolita petronella</i> (L. Pfeiffer, 1853)	0.84	-	-	-	-	2.94	-	0.85	-	-
<i>Daudebardia brevipes</i> (Drap., 1805)	-	-	-	0.72	-	-	-	-	-	-
<i>Daudebardia rufa</i> (Drap., 1805)	-	0.43	0.13	0.72	-	-	1.36	-	-	-
<i>Deroceras laeve</i> (Müll., 1774)	-	-	-	-	0.22	-	0.34	-	-	-
<i>Arion subfuscus</i> (Drap., 1805)	-	-	-	-	-	-	-	-	-	-
<i>Fruticicola fruticum</i> (Müll., 1774)	-	-	-	-	-	-	-	1.71	-	-
<i>Plicuteria lubomirskii</i> (Ślósarskii, 1881)	-	-	-	-	-	-	-	-	-	-
<i>Petasina unidentata</i> (Drap., 1805)	-	-	0.25	-	-	-	-	-	-	-
<i>Perforatella bidentata</i> (Gmelin, 1791)	0.42	9.94	-	12.41	3.69	1.35	-	0.85	-	0.27
<i>Monachoides incarnatus</i> (Müll., 1774)	-	0.22	0.25	1.19	-	-	0.34	-	-	-
<i>Pseudotrichia rubiginosa</i> (Rssm., 1838)	1.01	-	-	-	-	0.37	-	-	4.52	-
Total no. of individuals for each site	1192	463	799	419	461	816	295	117	199	373
Aquatic species										
<i>Bythinella austriaca</i> s.lat. (Frfld., 1857)	62.24	79.88	90.55	100	30.61	71.45	100	-	-	-
<i>Galba truncatula</i> (Müll., 1774)	1.79	1.78	9.45	-	18.37	-	-	4.89	0.25	-
<i>Radix peregra</i> (Müll., 1774)	2.68	11.83	-	-	-	-	-	-	3.98	1328
<i>Anisus leucostoma</i> (Millet, 1813)	-	-	-	-	-	-	-	-	40.05	391
<i>Pisidium casertanum</i> (Poli, 1791)	5.23	6.51	-	-	1.02	0.24	-	95.11	14.18	5703
<i>Pisidium milium</i> Held, 1836	0.64	-	-	-	-	-	-	-	-	2188
<i>Pisidium obtusale</i> (Lamarck, 1818)	-	-	-	-	-	0.82	-	-	26.12	391
<i>Pisidium personatum</i> Malm, 1855	27.30	-	-	-	50.00	27.50	-	-	-	-
<i>Pisidium subtruncatum</i> Malm, 1855	0.13	-	-	-	-	-	-	-	-	-
Total no. of individuals for each site	784	169	847	308	98	851	16	266	402	128

TABLE 2 - continued

Terrestrial species	11	12	13	14	15	16	17	18	19	20
<i>Vitrina pellucida</i> (Müll., 1774)	-	0.79	-	-	-	-	-	-	-	-
<i>Semilimax semilimax</i> (J. Fér., 1802)	-	-	-	-	-	-	-	-	-	-
<i>Vitrea crystallina</i> (Müll., 1774)	-	-	-	-	-	-	0.94	5.56	-	2.00
<i>Vitrea diaphana</i> (Studer, 1820)	-	-	-	-	-	-	-	-	-	-
<i>Vitrea transsylvanica</i> (Clessin, 1877)	-	-	-	-	-	-	-	-	-	-
<i>Aegopinella minor</i> (Stabile, 1864)	-	-	-	-	-	-	-	-	-	-
<i>Aegopinella pura</i> (Alder, 1830)	-	-	-	-	-	-	-	-	-	-
<i>Perpolita hammonis</i> (Stró'm, 1765)	1.16	46.43	4.44	0.93	2.49	1.20	4.38	16.67	-	-
<i>Perpolita petronella</i> (L. Pfeiffer, 1853)	-	-	0.37	4.17	-	-	-	2.78	-	-
<i>Daudebardia brevipes</i> (Drap., 1805)	-	-	-	-	-	-	-	-	-	-
<i>Daudebardia rufa</i> (Drap., 1805)	-	-	-	-	-	-	-	-	-	-
<i>Deroceras laeve</i> (Müll., 1774)	-	-	-	-	-	1.20	-	-	-	-
<i>Arion subfuscus</i> (Drap., 1805)	-	0.40	-	-	-	-	-	-	-	-
<i>Fruticicola fruticum</i> (Müll., 1774)	-	-	-	-	-	-	-	-	-	-
<i>Plicuteria lubomirskii</i> (Ślósarskii, 1881)	0.39	-	-	-	-	-	-	-	-	-
<i>Petasina unidentata</i> (Drap., 1805)	-	-	-	-	-	-	-	-	-	-
<i>Perforatella bidentata</i> (Gmelin, 1791)	-	-	-	-	0.23	-	-	-	-	-
<i>Monachoides incarnatus</i> (Müll., 1774)	-	-	-	-	-	-	-	-	-	-
<i>Pseudotrichia rubiginosa</i> (Rssm., 1838)	-	-	-	-	-	-	-	-	-	-
Total no. of individuals for each site	258	252	270	432	441	83	320	36	11	50
Aquatic species										
<i>Bythinella austriaca</i> s.lat. (Frfld., 1857)	0.09	-	-	-	-	4.39	-	-	-	50.00
<i>Galba truncatula</i> (Müll., 1774)	0.43	2.15	3.13	18.71	11.81	0.15	38.46	15.15	2.12	50.00
<i>Radix peregra</i> (Müll., 1774)	0.35	1.02	3.57	0.32	21.26	0.15	-	-	5.29	-
<i>Anisus leucostoma</i> (Millet, 1813)	9.71	18.82	-	1.29	-	-	-	-	15.87	-
<i>Pisidium casertanum</i> (Poli, 1791)	8.24	22.68	91.96	66.13	37.01	36.60	3.85	77.27	38.62	-
<i>Pisidium milium</i> Held, 1836	-	-	-	-	-	-	-	-	2.12	-
<i>Pisidium obtusale</i> (Lamarck, 1818)	-	-	-	-	29.92	-	-	-	-	-
<i>Pisidium personatum</i> Malm, 1855	81.18	55.33	1.34	13.55	-	58.71	57.69	7.58	35.98	-
<i>Pisidium subtruncatum</i> Malm, 1855	-	-	-	-	-	-	-	-	-	-
Total no. of individuals for each site	1153	882	224	310	127	683	52	66	189	2

TABLE 3

The mean, minimum, maximum values and standard deviation (S.D.) of the pH and conductivity ( $\mu\text{S}\cdot\text{cm}^{-1}$ ; 20 °C) in the particular types of fens: **A** - rich fens with tufa formation (10 sites), **B** - brown-moss rich fens without tufa formation (5 sites), **C** - rich *Sphagnum*-fens with occurrence of calcitolerant *Sphagnum* species (5 sites).

	type	mean	min.	max.	S.D.
	A	7.41	7.10	8.00	0.30
pH	B	6.96	6.80	7.10	0.11
	C	6.36	6.00	6.60	0.29
	A	384.60	309.00	443.00	39.11
cond.	B	325.20	165.00	485.00	120.84
	C	225.80	51.00	478.00	195.01

forming extremely rich fens of the *Carici flavae*-*Cratoneuretum*, but not in Carpathian travertine swards. Our results suggest that *V. geyeri* avoids fens with extremely high alkalinity and mineral richness (Fig. 8) such are the two latter mentioned habitats. This hypothesis is supported by an unimodal response of *V. geyeri* to the gradient of mineral richness measured as water conductivity (Fig. 7).

The occurrence of *V. geyeri* in boreal aapa mires (Valovirta, 2003) accords well with our findings. The minerotrophic structures in aapa mires, the flarks, harbour the set of species identical to Carpathian rich fens. The list of plant species associated with the occurrence of *V. geyeri* in north-west England (*Carex lepidocarpa*, *C. hostiana*, *C. dioica* and *Eleocharis quinqueflora*; Coles and Colville, 1979) corresponds to the species composition of such Carpathian vegetation in which *V. geyeri* reaches maximum abundance (Fig. 8). *Scorpidium cossonii* dominates the bottom vegetation layer across *V. geyeri* localities in both the Carpathians and the Fennoscandia (Pokryszko, 1993; Valovirta, 2003). The species presence in *Carex lasiocarpa*-dominated rich fen vegetation (Valovirta, 2003) is other common attribute of boreal and Carpathian distribution of the species. Our hypothesis of the *V. geyeri* affinity to fens not extremely alkaline is likewise supported by plant data published from boreal fens. The occurrence of calcitolerant *Sphagnum warnstorffii* (Pokryszko, 1993) as well as meadow species *Crepis paludosa*, *Filipendula ulmaria* and *Geum rivale* (Valovirta, 2003) indicates neutral or moderately alkaline environment, which is poor in calcareous tufa and not so extremely calcium-rich like fens dominated by *Palustriella commutata*.

The target species was recorded in two major rich-fen-vegetation types with equal constancy. Nevertheless, it gains higher abundance in *Caricetum davallianae* than in *Valeriano simplicifoliae*-*Caricetum flavae*. The habitat is rich in calcium carbonate particles such as unconsolidated tufa grains or lacustrine chalk in the former, whereas only scarce tufa grains are founding in the latter. Hence, the canopy of herbaceous vegetation is denser in *Valeriano*-*Caricetum flavae* (see right part of chart in Fig. 8) what can result in lowering snail abundance. The next ecological factors stressing snail populations in *Valeriano*-*Caricetum flavae* vegetation are an enhanced iron concentration (Horsák and Hájek, 2003) and, in some cases, an acidification caused by an autogenic succession (Hájková and Hájek, 2004). Due to low alkalinity as compared to other rich fen types, the part of localities is populated by the interspersed peat mosses, which form patches free of molluscs (Horsák and Hájek, 2003). In the light of recent changes in mires the potential threat to *V. geyeri* populations in existing localities therefore lies in eutrophication, which



TABLE 4

Synoptic table in fidelity (*Phi*-coefficient) values of four vegetation types classified by TWINSpan. Mean abundance of *Vertigo geyeri* is calculated for each type. The groups 1.1 and 1.2 were splitted from the groups 2.1 and 2.2 in the first division. Habitat and vegetation interpretation of the groups: 1.1 - Inner-Carpathian travertine swards (*Glauco-Trichophoretum pumili*); 1.2 - Inner-Carpathian peat- and lacustrine-chalk-forming alkaline fens (*Caricetum davalliana*); 2.1 - Outer-Carpathian peat-forming circumneutral rich fens, typical for (*Valeriano simplicifoliae-Caricetum flavae*); 2.2 - tufa-forming alkaline springs dominated by rich fen species (*Carici flavae-Cratoneuretum*).

Plant species	Group number	1.1	1.2	2.1	2.2
	Total no. of relevés	2	25	25	29
<i>Plantago maritima</i>		100.0	-	-	-
<i>Schoenoplectus tabernaemontani</i>		81.1	1.0	-	-
<i>Centaureum littorale</i> ssp. <i>uliginosum</i>		70.3	-	-	-
<i>Campylium elodes</i>		70.3	-	-	-
<i>Glaux maritima</i>		70.3	-	-	-
<i>Trichophorum pumilum</i>		69.8	-	-	-
<i>Triglochin maritima</i>		56.3	21.9	-	-
<i>Carex lepidocarpa</i>		-	71.8	-	-
<i>Primula farinosa</i>		25.3	64.6	-	-
<i>Tofieldia calyculata</i>		-	62.4	-	-
<i>Carex davalliana</i>		-	62.3	-	-
<i>Pinguicula vulgaris</i>		6.1	51.4	-	-
<i>Galium palustre</i>		-	-	60.7	-
<i>Aulacomnium palustre</i>		-	-	57.6	-
<i>Galium uliginosum</i>		-	-	57.6	-
<i>Calliergon giganteum</i>		-	-	56.2	-
<i>Valeriana simplicifolia</i>		-	-	53.3	-
<i>Agrostis canina</i>		-	-	52.9	-
<i>Philonotis fontana</i>		-	-	51.5	-
<i>Crepis paludosa</i>		-	-	51.5	-
<i>Angelica sylvestris</i>		-	-	50.7	-
<i>Juncus inflexus</i>		-	-	-	70.7
<i>Carex flacca</i>		-	-	-	61.7
<i>Lythrum salicaria</i>		-	-	-	56.4
<i>Eupatorium cannabinum</i>		-	-	-	53.4
<i>Agrostis stolonifera</i>		-	-	-	52.8
<i>Ajuga reptans</i>		-	-	-	51.5
The most often dominant species					
<i>Campylium stellatum</i>		+	-	-	-
<i>Trichophorum pumilum</i>		+	-	-	-
<i>Scorpidium cossonii</i>		-	+	+	-
<i>Cratoneuron commutatum</i>		-	-	-	+
Mean abundance of <i>Vertigo geyeri</i>		0	61	20	0

causes *Sphagnum* expansion (Koijmann and Kanne, 1993; Hájek, *et al.* 2002; Limpens, *et al.* 2003). The increase in aboveground vascular plant biomass following nutrient enrichment (Pauli, *et al.* 2002) can have also a potential negative role.

### ACKNOWLEDGEMENTS

Our thanks are due to colleagues, who participated in the field excursions, namely Daniel Dítě and Petra Hájková. This research project was supported by GA ČR 206/02/0568, GA AV ČR B601630501, and by MSM 0021622416.

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## APPENDIX

SURVEY OF SITES WITH THE OCCURRENCE OF *VERTIGO GEYERI* IN WESTERN CARPATHIANS

Data in the list are as follows: number of the site (bold), geographical co-ordinates (N, E), country (SK - Slovakia, PL - Poland), code of the mapping grid for faunistic mapping according to Pruner and Míka (1996) or databank of Fauna Slovakia, description of the site, elevation (m a.s.l., approximately), date of investigation, number of specimens (ex.).

**1** - 48°52'45", 18°53'24", SK, 7179, Rakšianské rašelinisko National Nature Reserve (= NNR), 512 m, 16. ix. 2001, 141 ex.; **2** - 49°09'45", 18°34'07", SK, 6877, Súľovské skály NNR - a fen in the valley of Černý brook, 424 m, 15. ix. 2001, 19 ex.; **3** - 49°21'36", 19°33'45", SK, 6683, Krivý kút - a fen 1100 m southwest of Uhlisko hill (near Trstená village), 759 m, 16. vi. 2002, 10 ex.; **4** - 49°09'59", 18°34'13", SK, 6877, Súľovské skály NNR - a fen in the valley of Černý brook, 623 m, 25.viii. 2002, 14 ex.; **5** - 49°24'16", 19°19'58", SK, 6581, a fen 1.5 km south of Beňadovské rašelinisko NR, 685 m, 17. vi. 2002, 21 ex.; **6** - 49°02'43", 19°34'45", SK, 6983, Demänovská valley - a fen 700 m southwest of Jamy hill, 650 m, 26. v. 2003, 85 ex.; **7** - 49°27'14", 19°27'39", SK, 6582, Ľaskovka NR near Klin village, 719 m, 16. vi. 2002, 3 ex.; **8** - 49°13'14", 20°22'28", SK, 6788, Vysoká Bazička - a fen 200 m west of southwestern margin of Belianske lúky NR, 699 m, 29. v. 2003, 19 ex.; **9** - 49°14'45", 20°28'04", SK, 6788, a fen near confluence of small brooks 1 km northwest of Podhorany village, 623, 29. v. 2003, 18 ex.; **10** - 49°03'03", 20°01'42", SK, 6986, Pastierske II - a fen near confluence of rivulets of Hlboký brook near Štrba village, 875 m, 26. v. 2003, 134 ex.; **11** - 49°16'18", 19°39'42", SK, 6783, Blatná dolina - a fen 2 km south of Mikulovka hill near Zuberec village, 800 m, 19. vi. 2002, 25 ex.; **12** - 49°21'18", 19°49'06", PL, 6684, a fen on south margin of Chocholów village, 800 m, 14. vi. 2002, 1 ex.; **13** - 49°05'27", 20°03'20", SK, 6986, a fen 900 m west of Tatranský Lieskovec village, 920 m, 28. v. 2003, 18 ex.; **14** - 49°17'28", 19°44'41", SK, 6784, Peciská II - a fen 1 km south of Oravice village, 810 m, 15. vi. 2002, 111 ex.; **15** - 49°12'52", 20°23'25", SK, 6788, Belianske lúky NR - northeastern part, 677 m, 29. v. 2003, 153 ex.; **16** - 49°31'29", 19°22'57", SK, 6482, Biela farma - a fen 150 m northwest of Dušák settlement near Sihelne village, 760 m, 17. vi. 2002, 11 ex.; **17** - 49°25'17", 19°19'44", SK, 6581, Beňadovské rašelinisko NR, 690 m, 17. vi. 2002, 24 ex.; **18** - 49°05'15", 20°02'43", SK, 6986, Pri Železnej vodě - a fen 1 km west of Tatranská Štrba village, 930 m, 28. v. 2003, 3 ex.; **19** - 49°07'59", 19°37'40", SK, 6883, Bariny - a fen 200 m south of Jalovec village, 680 m, 26. v. 2003, 1 ex.; **20** - 49°05'51", 20°02'03", SK, 6986, a fen on the left bank of Zasmrčianský brook near Tatranský Lieskovec village, 920 m, 28. v. 2003, 2 ex.

# STUDIES ON THE ROUND-MOUTHED WHORL SNAIL *VERTIGO GENESII* (GASTROPODA: VERTIGINIDAE) IN NORTHERN ENGLAND: OBSERVATIONS ON POPULATION DYNAMICS AND LIFE HISTORY

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*Abstract* Studies were carried out to investigate the wide-scale and small-scale distribution of *Vertigo genesii* (Gredler, 1856) in an area of Widdybank Fell in northern England over the period 2000 to 2003, to identify the critical features of the habitat that are essential to the survival of the snail, and to investigate the life history of *V. genesii*, in particular to determine significant times of the year for reproduction. This paper presents the results on the part of the project covering life history studies. There was an increase in abundance of *V. genesii* from August through to November in both 2000 and in 2002 although there was considerable variation throughout the study period. There was no defined time of year for a major reproductive event. Juveniles were present throughout the year and on average they comprised 55% of the population. Juvenile mortality was high. There does not appear to be a strong correlation between weather conditions and the species' reproductive cycle.

*Key words* *Vertigo*, whorl snails, life history, population dynamics, Habitats Directive

## INTRODUCTION

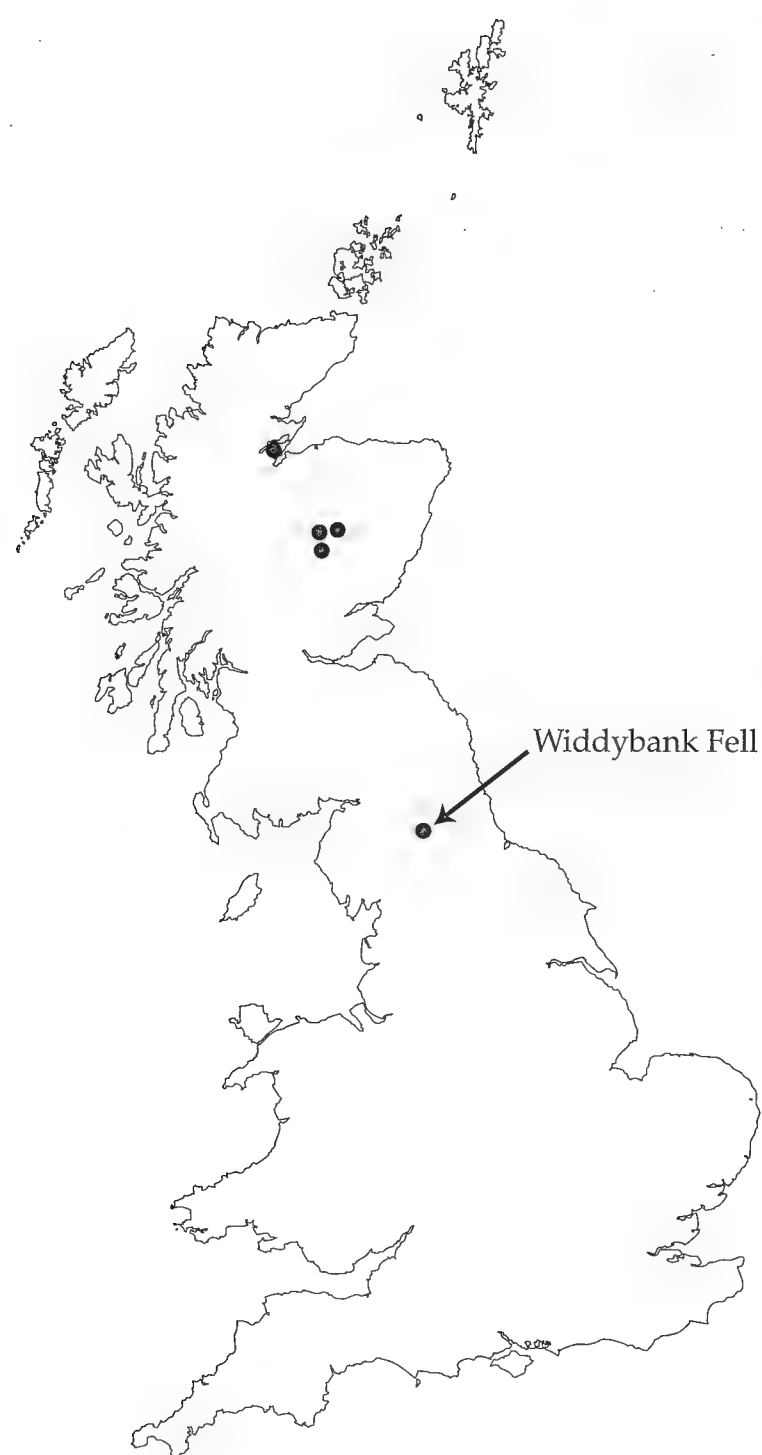
The round-mouthed whorl snail *Vertigo genesii* (Gredler, 1856) is an Arctic-Alpine species recorded from northern and central Europe. Most sites for the species are in central and northern Scandinavia, with a few in northern Britain, although its type locality is in Italy (Cameron *et al* 2003). It appears to be rare and in serious decline throughout its range. As a result of this decline, *V. genesii* is listed as Vulnerable on the IUCN/WCMC global list, and is listed on Annex II of the European Union Habitats and Species Directive.

In Britain, *Vertigo genesii* is a glacial relict which was frequent in the late Glacial and early Postglacial (Kerney 1999). Living populations were unknown in Britain until 1980 when it was discovered in calcareous flushes in Sand Sike on Widdybank Fell, Upper Teesdale (Coles & Colville 1980). It was subsequently classified in the British Red Data Book (Bratton 1991) as RDB1 (Endangered), and included on the 'short-list' of priority species on the UK Biodiversity Action Plan (BAP) (HMSO 1996). In addition, *V. genesii* is listed on the County Durham BAP and Northumbrian Water BAP, the first corporate BAP in the country.

Since 1995, *Vertigo genesii* has been found at other sites in a cluster of sites in the valley of the River Tees in Moor House-Upper Teesdale National Nature Reserve in England, and around Blair Atholl, Perthshire and the Black Isle on the Moray Firth, both in Scotland (Killeen 2003a) (Figure 1).

The species occurs in soligenous fens and mires, wet flushes and constantly humid meadows that are calcareous and have a high pH (Pokryszko 1990, Cameron *et al* 2003, von Proschwitz 2003). It lives at the base of short sedges, particularly *Carex viridula* ssp. *brachyrrhyncha*, and mosses, especially *Palustriella* (syn. *Cratoneuron*) spp (Killeen & Colville 1999, Killeen 2000a). It occurs where the substrates are at or near field capacity, in often incompletely vegetated, rather stony or gravelly wet flushes (on sloping ground) not subject to flooding (Cameron *et al* 2003). It has also been found in the splash zone of large waterfalls in Finland (Valovirta 2003). *Vertigo genesii* occurs mainly at altitudes between 300 and 900 metres, but has been recorded as low as 75m at the Black Isle site in

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**Figure 1** Distribution of *Vertigo genesii* in Britain

the life history of *V. genesii*, in particular to determine significant times of the year for reproduction. This paper describes the part of the project covering life history studies.

### THE STUDY AREA

At a significant proportion of its known sites in Britain (including all in Scotland), and also many in Scandinavia, *Vertigo genesii* co-occurs with *V. geyeri* Lindholm, 1925. Whilst adults can be separated by the presence of apertural teeth in *V. geyeri*, juveniles (which have no teeth) cannot be reliably separated. Thus, in mixed populations, detailed ecological and life history studies are not possible. Upper Teesdale appears to be unique amongst British sites in that *V. genesii* does not co-occur with *V. geyeri*, although the latter species is known from several sites further west in the northern Pennines (Killeen 2000b). Therefore, Widdybank Fell provided the ideal site for this study.

Widdybank Fell is part of Moor House-Upper Teesdale NNR and is bounded by Cow Green Reservoir to the west and the River Tees to the south. It rises from an altitude of 400m in the Tees valley to 585m at the summit. The Fell forms part of the Whin Sill and has extensive areas of limestone. A range of habitats occur including: grouse moor, blanket bog, limestone grassland and flushes. Hydrological and geological factors combine to give rise to springs and upwellings at locations around the hillside. These

Scotland, and as high as 2000m in the Alps.

In her review of the *Vertigo* of continental Europe, Pokryszko (2003) states 'that a great majority of the information is a by-product of faunistic and systematic research, publications dealing specifically with ecology, population biology, life cycles or population genetics being very few or non-existent'. The species of *Vertigo* whose life history has been studied in the greatest detail is *V. pusilla* (Pokryszko 1992). Most of the information has come from laboratory studies, and the species lives in drier habitats compared to most other *Vertigo* species. An account of the life histories of *Vertigo angustior* in south Wales and *V. geyeri* on Anglesey is given by Cameron (2003).

Hitherto, there has been very little published information specifically on *Vertigo genesii* distribution and fine ecology within sites, and virtually no information on the species' life history. Descriptions and illustrations of the reproductive system of *V. genesii* are given by Pokryszko (1990). Pokryszko (1987) found that of 6 adult individuals examined from Widdybank Fell, 2 were euphallic and 4 were aphyallic.

In 2000, Northumbrian Water initiated and funded a project to investigate the wide-scale and small-scale distribution of *V. genesii* in an area of Widdybank Fell, to identify the critical features of the habitat that are essential to the survival of the snail, and to investigate



springs give rise to flushes and trickles which merge to become small stream valleys known as sikes. In some locations on Widdybank Fell, these springs and upwellings are calcareous and tufa-depositing, and create flushed slopes with a rich upland fen plant community.

One of the most extensive flush complexes in Upper Teesdale lies in the valley of Sand Sike on the northern slopes of Widdybank Fell. A previous study (Killeen & Colville 1999) showed that this complex was the site on Widdybank Fell where *Vertigo genesii* was most widespread and relatively abundant. This area was therefore selected as being the most appropriate for the present study and that which could support a programme of detailed sampling.

A flush slope at the eastern end of the Sand Sike complex was selected for the location of 3 permanent plots (National Grid Reference NY827306). Plot A measured 10m from West to East and 15m from South to North and was located 2m downslope of the spring head. Plot B (20m x 20m) was located 5m to the north of Plot A, and Plot C (20m x 20m) was located 5m to the north of Plot B. The 3 plots were securely marked with 5cm x 5cm wooden stakes hammered into the corners of each. The spring head lies at an altitude of 475m and the bottom of Plot C at 465m. The gradient of the slope was approximately 8 degrees.

## METHODS

*Sampling frequency* Samples were taken on 13 occasions over the period August 2000 to April 2003. Due to the outbreak of foot & mouth disease in 2001, the bulk of the sampling was carried out between March and November 2002.

*Snail sample collection* *Vertigo genesii* was collected by sampling vegetation from a quadrat area measuring 20cm x 20cm (0.04 m<sup>2</sup>). The vegetation was cut at ground level using a sharp knife with a serrated blade. Only moss mounds and sward with small tussocks comprising mainly sedge, grasses and interstitial moss were collected. The sample sites in the plots were determined randomly within potentially suitable habitat. Their locations were recorded, along with a brief description of the habitat at the sample point. The samples of vegetation were labeled and placed in fine-mesh nylon bags. The number of samples taken per visit ranged from 7 to 15.

Large rocks, bare ground, habitat that was permanently under water, and areas with rare and higher plant species were not sampled. Care was taken to avoid re-sampling quadrats which had been sampled in the 3 months previous.

*Snail sample analysis* The vegetative material was teased apart and spread on sheets of newspaper. The percentage composition by volume of moss and sedge/rush/grass was estimated. When the vegetation sample was dry, it was further teased apart and shaken over a 5 mm sieve to remove the bulk of the plant material but to allow all molluscs to pass through. The residue was passed over a graded stack of sieves (smallest mesh size 0.5mm) and examined microscopically. All molluscs were picked out, identified and counted. Specimens of *Vertigo genesii* were categorized as living or dead shells, adult and juvenile.

*Population size structure* The size structure of the *V. genesii* population was determined according to the number of shell whorls. Initially all of the *V. genesii* individuals were categorised into 3 groups: less than half grown individuals (1.25 to 3 whorls), more than half grown i.e. sub-adult (3.25 to 4.5 whorls), and adults (4.75 whorls). The method of whorl measurement followed that described in Kerney & Cameron (1979). All adults, i.e. those characterised by a thickening of the outer lip of the shell aperture were classed

as having 4.75 whorls. The smallest individuals have 1.25 whorls and are considered to be the size at which the snails hatch from their eggs.

To enable a more accurate interpretation of temporal change in the *V. genesii* population structure, a number of samples were selected for detailed size analysis. For this analysis the number of whorls of each specimen of *V. genesii* was determined and assigned to individual ¼ whorl size classes. For each month, one or two of the plot samples (usually from Plot A) containing 60-150 juveniles was selected for the more detailed size analysis (see Table 9 for the samples selected). In the case of June 2002, the specimens from all 8 samples were amalgamated.

*Weather information* Meteorological data was obtained for the Moor House station located at an altitude of 555m, and approximately 6km west of the Sand Sike study area (Grid Reference NY757328). Data covering the period June 2000 to June 2003 was obtained for Maximum and Minimum temperature, frost days, soil temperature, relative humidity, total rainfall and number of days with rain.

RESULTS

Table 1 gives a summary of the number of samples taken, the number of positive sites and the mean numbers, range and standard deviation of *Vertigo genesii*. Of the 151 samples taken, 121 contained *V. genesii*. An overall mean for all samples was 27.1, equivalent to a density of approximately 680 individuals/m<sup>2</sup>.

TABLE 1  
Summary of results - numbers of samples, number of *V. genesii*/sample

	<i>Vertigo genesii</i>				
	No. of samples	No. of +ve samples	Mean No. of individuals/sample	Range	σn-1
01 August 2000	15	12	16.5	0-88	27.2
01 September 2000	15	14	31.8	0-238	60.1
01 November 2000	15	11	51.3	0-272	81.3
16 February 2001	7	7	38.6	5-161	56.1
22 March 2002	15	13	35	0-127	42.7
25 April 2002	8	6	4.0	0-18	6.21
13 May 2002	8	5	29.7	0-130	55.2
17 June 2002	12	10	6.7	0-22	6.75
26 July 2002	12	10	30.2	0-93	30.7
24 August 2002	12	12	20	1-87	26.3
26 September 2002	12	12	28.6	4-103	28.6
04 November 2002	12	12	39.8	1-174	48.7
22 April 2002	8	7	3.6	0-11	4.10

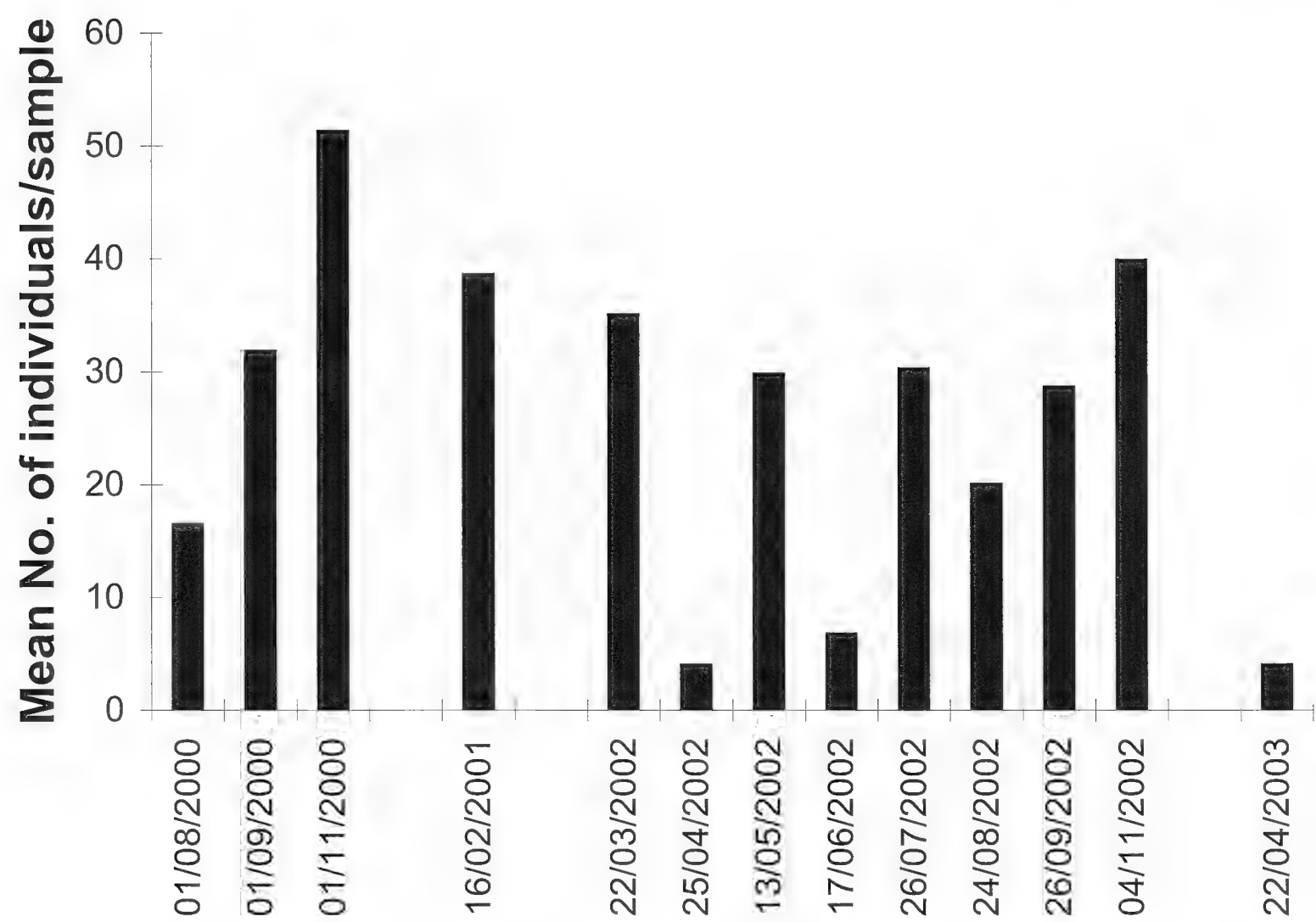


Figure 2 Temporal change in number of *V. genesii*/month

ABUNDANCE

The mean numbers of individuals (Figure 2) indicate an increase in abundance of *V. genesii* from August through to November in both 2000 and in 2002. There is considerable variation, however, throughout the year, with relatively high numbers (>25 individuals/sample) recorded in February 2001 and in March, May and July 2002, with low numbers in between (<7 individuals/sample) recorded in April and June 2002 and again in April 2003.

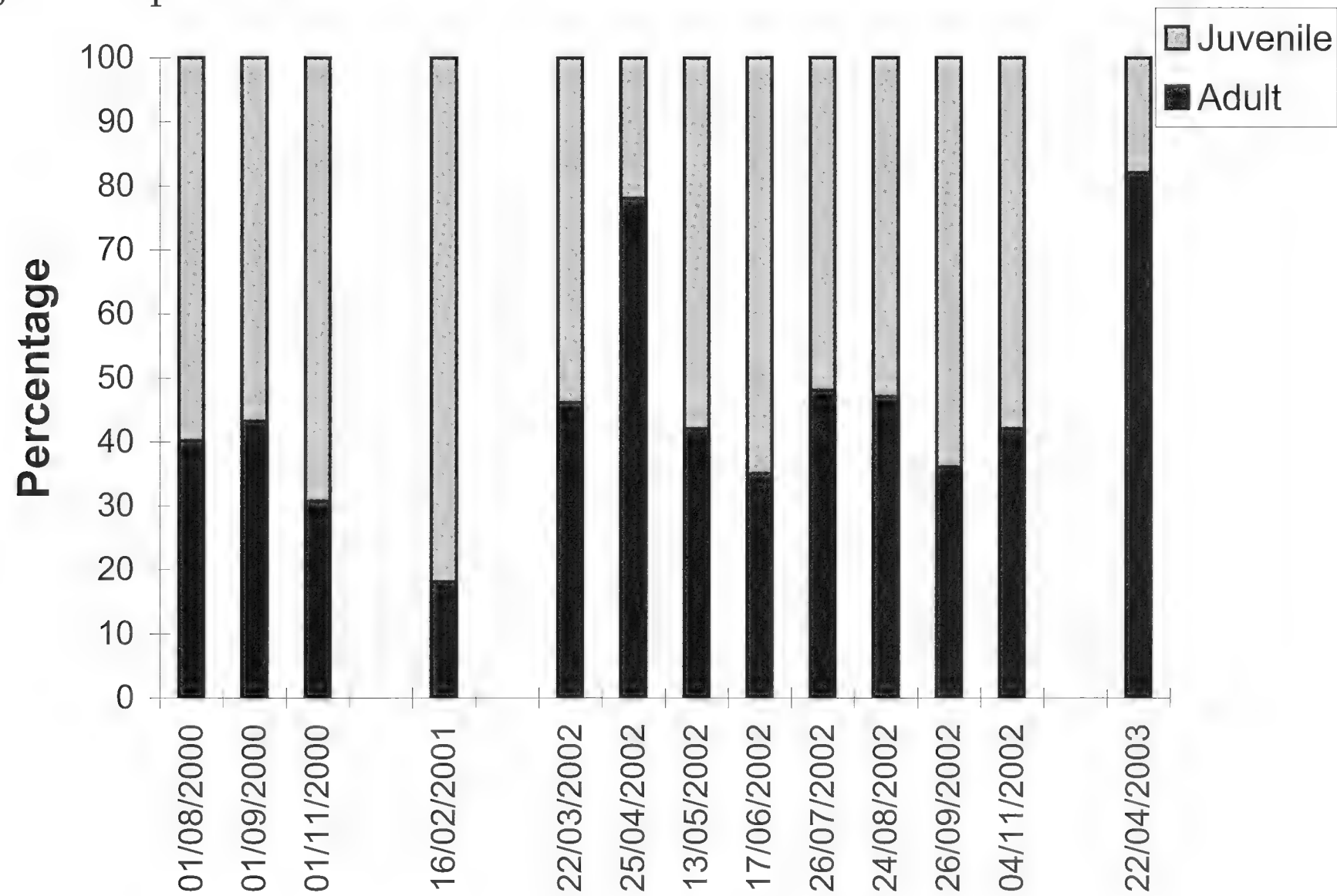


Figure 3 Percentage adults/juveniles in the plots combined



POPULATION STRUCTURE

There was no defined time of year for a major reproductive event. Juveniles were present throughout the year and on average they comprised 55% of the population (Figure 3).

In April 2002 and April 2003 the percentage of juveniles was 22% and 18% respectively. However, in both cases the sample size was small, 32 individuals in April 2002 and 29 individuals in April 2003. For all other sampling occasions, the percentage of juveniles in the population ranged from 52% (July 2002) to 82% (February 2001) with a mean of 62%. These results show that there was an increase in the juvenile proportion of the *V. genesii* population from September 2000 to February 2001, but otherwise there are no clear trends.

There are large differences in the proportions of the two *V. genesii* juvenile population size classes (Figure 4). Excluding the data from April 2002 and 2003, juveniles comprised 62% of all individuals in the population. However, 52% of the population comprised individuals of 3 whorls or less and only 10% of individuals had shells with 3.25 to 4.5 whorls i.e. sub-adults. There were no sampling occasions in which sub-adults outnumbered juveniles. The percentage of sub-adult individuals in the population ranged from 4% in February 2001 to 20.6% in August 2000. Generally sub-adults comprised <10% of the individuals, and only comprised a higher proportion on 3 occasions (August 2000 – 20.6%, June 2002 – 17.3%, and March 2002 – 12.5%). These results strongly indicate that juvenile mortality is very high. However, the time spent at the sub-adult stage may also be very short. There were not large differences between the results from the overall population and those from the samples selected for accurate whorl counts, and, therefore the selected samples were considered to be sufficiently representative to give an indication of trends in growth and periods of recruitment.

The percentage of individuals in each ¼ whorl size class, including the proportion of adults (with 4.75 whorls) for the selected samples, on a month by month basis is shown in Figure 5. The samples from April 2002 and April 2003 were excluded from this analysis as the *V. genesii* numbers were so low.

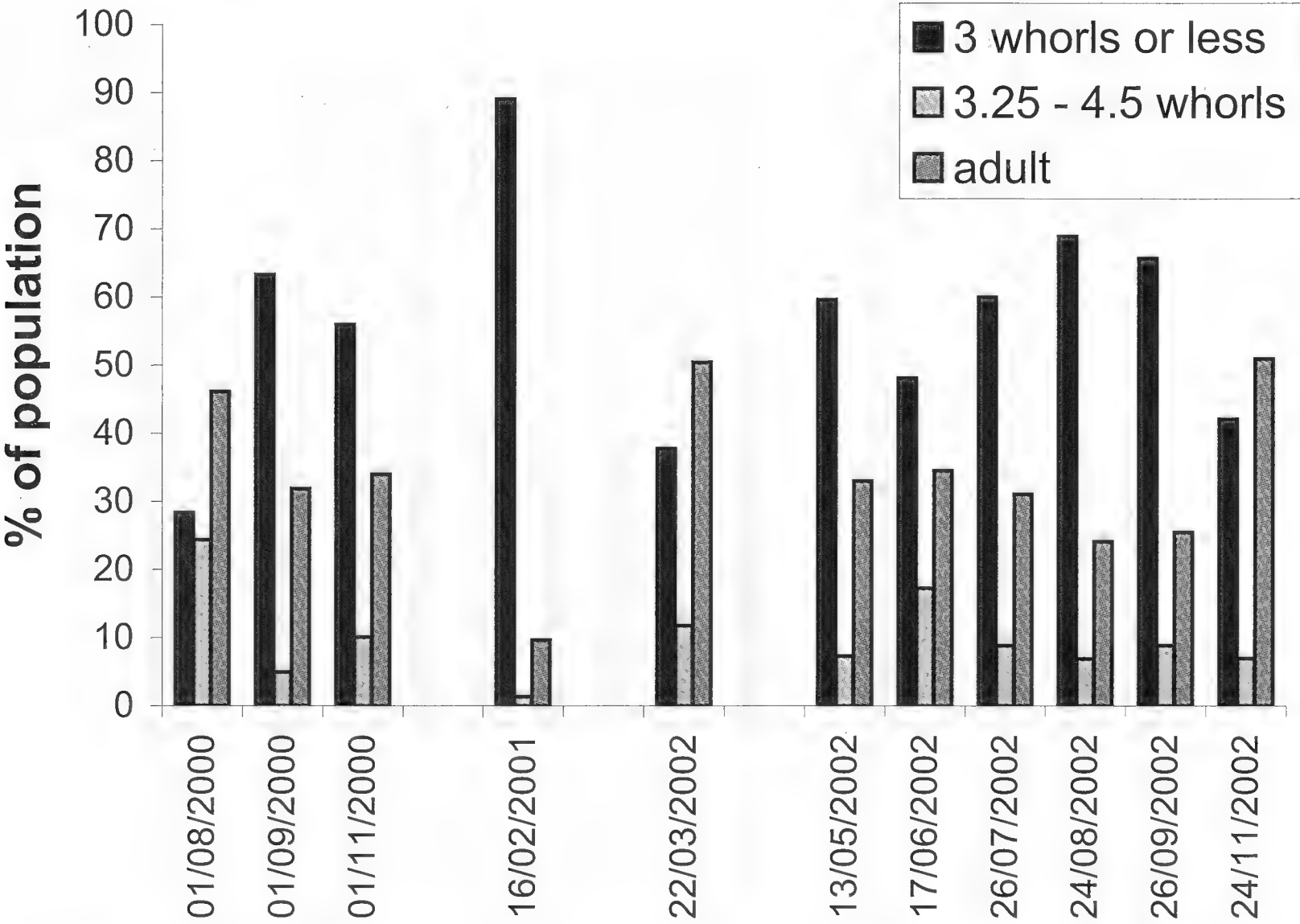


Figure 4 Temporal change in the *V. genesii* population structure (all samples)

In August 2000, only 4% of the juveniles were small (i.e. 2 whorls or less). In September 2000 there had been a period of recruitment and 62% of the juveniles were small. The graph for 01 November 2000 mostly shows a period of growth but there was some further recruitment with 30% of the juveniles with 2 whorls or less. Between November 2000 and 16 February 2001 there was a further period of recruitment with 82% of the juveniles having 2 or less whorls. The very low percentage of sub-adults and adults in February 2001 indicated a high mortality over the winter.

In 2002 the measurements from March through to July showed periods of low recruitment and growth. Small juveniles comprised 19%, 33%, 15%, and 8% of all juveniles for the months of March, May, June and July respectively. By 24 August 2002, there had been a period of recruitment with 74% of the juveniles having 2 or less whorls. Recruitment continued over the following month so that on 26 September the small-shelled juvenile proportion was still high (68%). However, the sparsity of sub-adults and the level of adults similar to August again suggests a high mortality. By 04 November, there was less recruitment but the juveniles had grown such that only 25% of the non-adults were small and 74% had between 2.25 and 3.5 whorls. Thus, *V. genesii* appears to reproduce opportunistically throughout the year, but with the largest recruitment period occurring between August and March.

#### WEATHER DATA

The warmest months were either July or August with mean daily maxima reaching just over 15°C and mean daily minima around 8°C. January and February were generally the coldest months with mean daily maxima rarely exceeding 4.5°C and with minima below zero. There were a high number of days with frost with over 10 days/month recorded between November and April. During the winter (December to February) the number of frost days exceeded 20. Soil temperature at 10cm followed the same pattern as for maximum and minimum temperatures. Relative humidity was high in the winter and low in spring/summer. During the period of the current project periods of high rainfall occurred in autumn and winter and low rainfall in spring and summer.

Low temperature would not appear to be a key factor in the reproductive cycle of *V. genesii* at Widdybank Fell. The population was showing strong recruitment in the winter of 2000-2001 when maximum temperatures were below 4°C and minimum temperatures were sub-zero. Similarly there was a period of recruitment in late winter 2002. High numbers of frost days and low soil temperatures were coincidental with these periods of recruitment.

#### DISCUSSION

The current study has yielded new information on the population biology and life history of *Vertigo genesii* at Sand Sike on Widdybank Fell. There is evidence of almost continuous reproduction throughout the year, with the lowest period of reproductivity being in Spring and early summer, which greatly contradicts the main reproductive period suggested by the only published database for non-marine molluscan life history traits (Falkner *et al.* 2001), given as April to July. It is possible and indeed likely that the wider reproductive spread of the UK population is due to the less extreme climate in Widdybank Fell compared with the European arctic-alpine habitats in Finland, Sweden and Italy. As the UK populations are likely to be at the climatic edge of this species range, the long term threat of global warming to the UK populations should not be underestimated.

As short-lived animals with rapid growth, populations of *Vertigo* species undergo

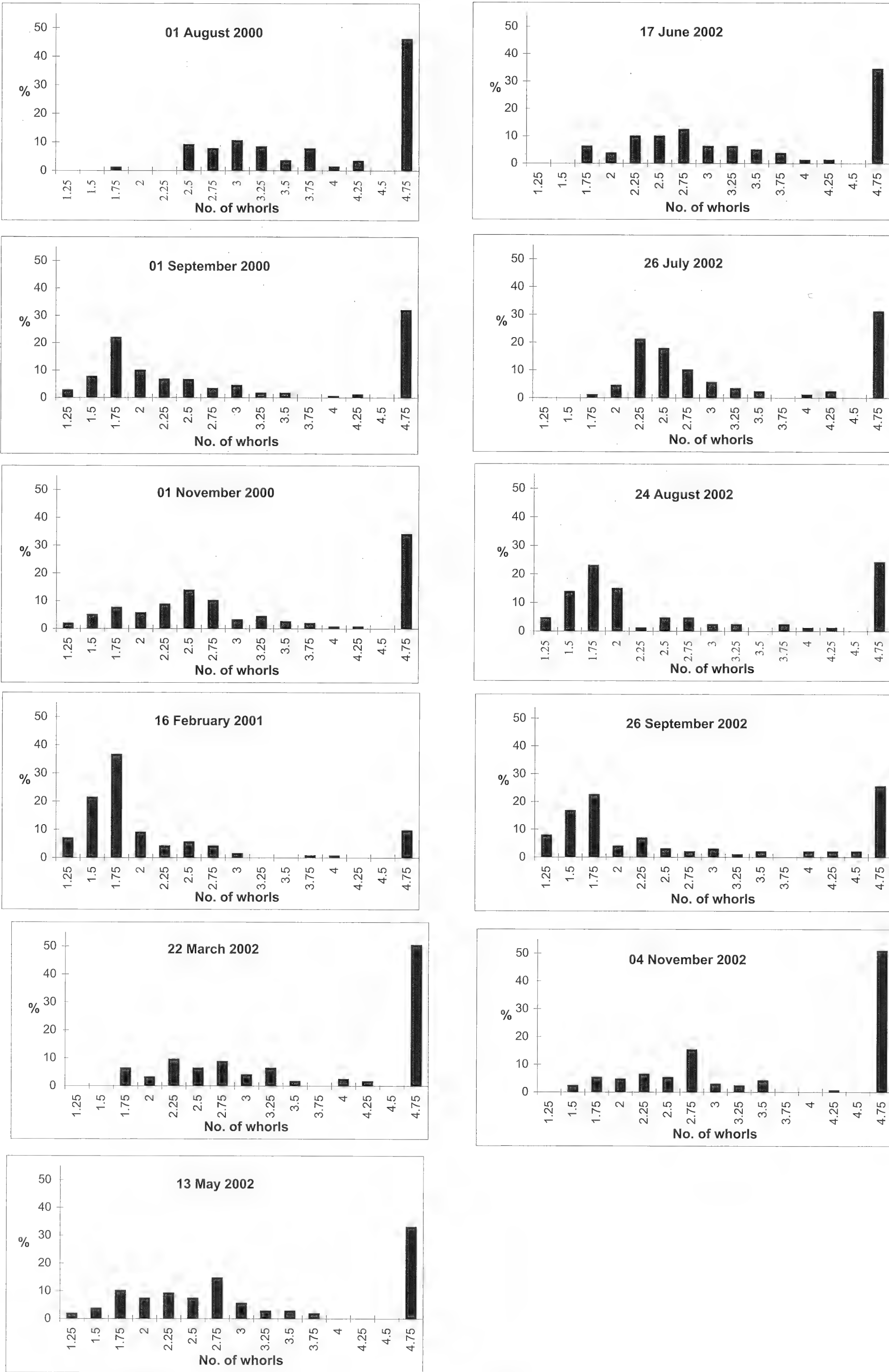


Figure 5 *Vertigo genesii* size distribution (selected samples)



drastic seasonal fluctuations in density and age structure. The ability of *Vertigo* species to reproduce uniparentally significantly aids the life strategy. At times of the year when adult individuals may be relatively few and widely dispersed, such as in winter or following a period of drought, the probability of two individuals meeting is at its lowest. By uniparental reproduction, the low numbers of individuals are able to reconstruct the population in a few weeks (Pokryszko 1987). Moreover, a single coloniser is able to establish a new population.

Some studies (e.g. Pokryszko 1992, Sharland 2000, Cameron, 2003, Killeen 2003b) of populations of other species of *Vertigo* have shown clear temporal trends in population density and structure. For *V. pusilla*, Pokryszko (1992) found the population density increased rapidly from c. 120/m<sup>2</sup> in February to a maximum of c. 800/m<sup>2</sup> in April, May and June. At the same time the percentage of juveniles increased from a few or 0% in February to the maximum of >80% in April. Sharland (2000) found that field sampling of a *Vertigo angustior* population at Whiteford Burrows, south Wales, gave highest densities of individuals in October and November. Adults dominated in the population in June and July (c. 80% of all individuals), whereas in November 60-70% of individuals were juveniles. A similar pattern was found for *Vertigo moulinsiana* at Thatcham in southern England between 1997 and 2001 (Killeen 2003b). Densities were at their lowest in June and at their peak in October/November. Adults were dominant in July (c. 80-90% of all individuals), whereas in October >70% of individuals were juvenile. Another study on *V. angustior* at Gait Barrows in northwest England (Killeen 1998) showed large differences in the juvenile component between years. In October 1996 the population was dominated by adults (82.4%), whereas in October 1998 adults comprised only 42.4%. In the *Vertigo geyeri* population on Anglesey, juveniles were present at all times of year but peaks of new recruits were recorded in late summer 1998 and in autumn 1999 (Cameron 2003, Sharland 2000). In 1998, the population density increased steadily from April through to October, but in 1999 the density was much lower and showed no increase until the September phase of recruitment.

The above studies suggest that while opportunistic breeding of other *Vertigo* species occurs at various times during the year, the bulk of the population for the next year is provided by the recruitment from a major breeding event. The observations from this study suggest that *V. genesii* at Widdybank Fell is sustained over time only by its continuous and opportunistic reproduction (i.e. there is no major breeding event). If this is the case, then *V. genesii* populations may have difficulty in recovering from events such as prolonged drought that could cause high mortality. The potential vulnerability of *V. genesii* increases the importance of maintenance of the appropriate habitat management and site conservation for the species survival.

#### ACKNOWLEDGEMENTS

This project was funded by Northumbrian Water as part of their contribution towards local conservation of biodiversity, to whom I extend my thanks. I am especially grateful to Dr Chris Spray for his continued interest and support throughout the project. My thanks are also due to the Riby Estate for permission to work on Widdybank Fell. The local English Nature team at Widdybank Farm provided support, and in particular I thank Chris McCarty for his enthusiasm and interest, for liaising with the Estate and for logistical help. Dr Barry Colville assisted on many of the sampling visits and picked some of the samples. Finally I would like to thank Dr Evelyn Moorkens for assisting on field sampling visits, sharing her knowledge on *Vertigo* ecology and for her invaluable help in preparation of this paper.

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## COCHLICOPA NITENS (COCHLICOPIIDAE) LIVING IN NORTHERN FRANCE

*Cochlicopa nitens* (M. von Gallenstein, 1848) is a very rare species, living in oligotrophic calcareous swamps in the floodplains of large rivers or in the neighbouring large lakes<sup>1</sup>. The most western living occurrences of *Cochlicopa nitens* came from eastern France, where it was found by Geissert<sup>2</sup> in the Offendorf natural reserve, a flooded forest of the Rhine River plain in Alsace.

In May 2002, two living populations of *Cochlicopa nitens* were found in the Dept. Nord by the first author. One adult specimen was firstly recorded from Hergnies (N.W. of Valenciennes) in a small calcareous swamp tributary of the Scheldt River, flooded by cold springs. Then, many specimens (adults and juveniles) were collected in a very oligotrophic calcareous swamp located at Vred (S.E. of Douai), in the flooded plain of the Scarpe River. The latter locality is characterised by a very pronounced continental micro-climate. The temperature is quite lower than elsewhere in the region, late frosts often occur in late spring. In late August 2004, *Cochlicopa nitens* was found by both authors in the lower valley of the Somme River at Belloy-sur-Somme (Dept. Somme) a few kilometers west of Amiens. Many snails were observed under logs and in the leaf litter of a large calcareous swamp.

In each case, amongst other species, *Vertigo moulinsiana* (Dupuy, 1849) was found as well. These localities in Northern France thus represent a considerable extension of the continental distribution of the species to the west. These data filled the gap between fossil records found in Great Britain<sup>3</sup> and the most occidental population still living in Eastern France.

Thanks are due to Margrit and Gerhard Falkner for confirming our shells.

<sup>1</sup> FALKNER G, RIPKEN T.E.J. & FALKNER M. 2002 *Mollusques continentaux de France*. Liste de référence annotée et Bibliographie. MNHN, Paris.

<sup>2</sup> GEISSERT F. 1997 *Bull. Ass. Philom. Alsace Lorr.* **32**: 29-67.

<sup>3</sup> PREECE R.C. 1992 *J Conch.* **34**: 215-224.

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## VERTIGO SUBSTRIATA & VERTIGO ANGUSTIOR IN NORTHERN FRANCE

This communication summarizes some noteworthy records of non-marine molluscs of the region of Nord/Pas-de-Calais. These observations were carried out between the years 1999 and 2001, during two studies commissioned by the "Conseil Général du Nord" and the "Conservatoire des Sites Naturels du Nord et du Pas-de-Calais". Here will be given three new records of *Vertigo substriata* (Jeffreys, 1833) and two new records of *Vertigo angustior* Jeffreys, 1830. Each record will be briefly described and some notes



about other molluscs found with these species will be also given.

*Vertigo substriata*:

Nord; Herzeele : Reserve Naturelle Volontaire du Vallon de la Petite Becque, 25 km S of Dunkerque (DS 63), 14/07/1999. This record was placed in a tall herbs community dominated by *Filipendula ulmaria*. Curiously at this place, there was no other species of Vertiginidae although the site showed numerous suitable habitats for species belonging this family.

Nord; Saint-Jans-Cappel: Mont-Noir, about 20 km NW of Lille (DS 82), 20/12/2000. *Vertigo substriata* was discovered among moss under a very important station of *Scirpus silvaticus*, next to a little runnel. This snail was discovered alive with *Nesovitrea hammonis*, *Carychium minimum* and *Deroceras laeve*.

Nord; Eppe-Sauvage, Bois Départemental de Nostrimont, about 70 km SW of Valenciennes (ER 85). *Vertigo substriata* was found alive on leaves of *Scirpus silvaticus*, next to a spring of freshwater with *Carychium minimum*, *Deroceras laeve*, *Nesovitrea hammonis* and *Euconulus* sp.

*Vertigo angustior*:

Pas-de-Calais; Le Touquet-Paris-Plage, Dune de Mayville, 30 km S of Boulogne sur Mer (CR 99), 01/07/2000. The site where *Vertigo angustior* was found is a sand dune. It was discovered in abundance in leaf litter of a wood of *Populus tremula*. The other species associated with *Vertigo angustior* are *Lauria cylindracea*, *Trichia hispida* and *Aegopinella pura*.

Pas-de-Calais; Camiers, Réserve Naturelle de la Baie de Canche, about 30 Km S of Boulogne sur Mer (DS 00), 15/11/2001. *Vertigo angustior* was discovered in a sand dune. The habitat is an edge of wood of *Salix* sp. *V. angustior* was found with *Vertigo pygmaea* in moss under *Holcus lanatus* and *Urtica dioica*.

*Vertigo substriata* was not quoted from North of France (Nord and Pas-de-Calais) by Germain<sup>1</sup>. It is the first time that this snail is found in the department of Nord. The first observations seem to show that this species is associated with habitats more peculiar than other species of Vertiginidae. These habitats reveal some characteristics of continental climatic conditions reflected by the presence of the continental plant specie *Scirpus silvaticus*. Since *V. substriata* is a boreal species, its occurrence in the Nord/Pas-de-Calais seems to indicate that these populations constitute postglacial relics. *Vertigo angustior* seems to be located only in coastal sand dunes of this region. At present, no records are quoted from Eastern parts of Nord/Pas-de-Calais. This species, in the Nord/Pas-de-Calais, is interesting since it is listed on EC Habitat Directive and these two records are located in two NATURA 2000 sites.

<sup>1</sup> GERMAIN 1931 *Faune de France Mollusques terrestres et fluviatile*, ed P. Chevalier, Paris.

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## THE GENUS *PHOLEOTERAS* STURANY, 1904, IN GREECE (GASTROPODA, CAENOCASTROPODA, CYCLOPHORIDAE)

While describing *Pholeoteras zilchi* Subai, 1993, from the mainland of Ipiros, Greece, Subai<sup>1</sup> did not question the earlier record of *P. euthrix* Sturany, 1904, from the Ionian island of Kerkyra (= Corfu) by Gittenberger<sup>2</sup>. However, the two records of troglodytic *Pholeoteras* in Greece are nearly 100 km apart, whereas the gap between the occurrence in Kerkyra and the well-known main range of *P. euthrix* in Croatia<sup>3</sup> is much larger, i.e. about 350 km. Therefore, we speculated that *P. zilchi* might occur in Corfu instead of *P. euthrix*. The Corfu material had not been studied very critically, since, when a *Pholeoteras* species was recorded in Corfu, this Old-Tertiary relic genus<sup>2,3</sup> was still considered monotypic. (There have been no additional records from Corfu, maybe because the Grava Tsouca is not a touristic cave and cannot easily be located).

We have studied the two specimens of *Pholeoteras* from Kerkyra once more and compared them with shells of *P. euthrix* from Croatia and paratypes of *P. zilchi*. We could only confirm the previous identifications. It has to be concluded that there are at least two *Pholeoteras* species represented in Greece, both known in that country from a single locality only.

This note is based on material in the National Museum of Natural History, Leiden, The Netherlands.

<sup>1</sup> SUBAI P. 1993 *Arch. Molluskenk.* **122**: 63-69.

<sup>2</sup> GITTENBERGER E. 1977. *Com. 6è. Simp. d'Esp., Bioesp., Terrassa, 1977.* pp 47-53.

<sup>3</sup> BOLE J. 1975 *Razprave Diss., Slovenska Akad. Znan. Umetn. (IV, Hist. Nat.)* **18/2**: 33-46.

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## ANOTHER MEDITERRANEAN LAND-SNAIL FOUND IN UK

At the end of March 2005 a juvenile of *Rumina* cf *decollata* (L, 1758) was found on a lavender plant purchased from a garden centre in Caerphilly, South Wales. The lavender plant had been imported from Italy, and from the condition of the material the snail was presumed to have been living when it was received by the garden centre. The remains of a dark-grey body are apparent in the shell.

The shell was compared with other shells in National Museum of Wales, and has been deposited there by the finder, Matthew Pickard (NMW.Z 2005.007.00001). The size of the juvenile matched juveniles in material from Spain and Madeira, and given the probable body colour the specimen is believed to be *Rumina decollata* (L.) rather than *Rumina saharica* Pallary, 1901. However, as Carr<sup>1</sup> points out the shell characters are not always reliable and mature specimens for dissection may be necessary for species determination.

Other Mediterranean species, such as *Hygromia cinctella* (Draparnaud, 1805) have now become more common in UK gardens, and the NMGW Alien snail recording scheme has records from Glamorganshire, Pembrokeshire, Berkshire, Sheffield, North Wales<sup>2,3</sup>. Species such as *Paralaoma servilis* (Shuttleworth, 1852)(= *Paralaoma caputspinulae* Reeve, 1854 or *Punctum pusillum* Lowe, 1831) were first recorded in garden centres and eventually found to be living outside. This may be a species that we need to be aware of in future garden surveys, although winter frosts should make it difficult for the species to become established.

<sup>1</sup> CARR R. 2002 *J. Conch.* p. 569-577.

<sup>2</sup> COWELL D. 2003 *Mollusc World* 1 pp. 7, 18-19.

<sup>3</sup> COWELL D. 2003 *Mollusc World* 2 p. 15.

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## BOOK REVIEW

*Field guide to the land snails and slugs of eastern South Africa*, Dai Herbert and Dick Kilburn, Natal Museum, Pietermaritzburg, South Africa. ISBN 0-620-32415-5 Cost SAR 290 (c. £24.50) plus postage (surface mail SAR 100 (c. £8.50), airmail is SAR 200 (£17).

The authors are based at the Natal Museum where they have collaborated on this book for many years. When they started on this project it was a new departure on to dry land, as they were both marine malacologists. The volume has been produced as part of the Natal Museum's centenary celebrations and celebrates 100 years of malacological research at the Museum.

I highly recommend purchase, as this book sets a new standard for field guides in the field of Molluscan studies. It succeeds in being both a comprehensive guide to the land snails of eastern South Africa as well as providing much information about life cycles and animal biology for the region. For a new student the book is self-contained, guiding a student through collection and preservation techniques, to identification and does not require access to other books on the other aspects of snail biology. Dai Herbert has added sections on snail farming and pest species reflecting his expertise on this area. It synthesises this information without putting too many additional pages onto the book, hence it remains a useful book to take with you on a field trip.

There are 336 pages to the guide, with full colour printing throughout. The book covers the identification of 284 species, and 127 of these are endemic to eastern Southern Africa. All 284 species are illustrated, some with more than one picture. There are many introductory diagrams and maps, reflecting the principle that diagrams can synthesise and present complex information more effectively than words, and all the diagrams are used in the descriptive accounts. Each species entry included a picture of the shell, often in colour, and sometimes with an illustration of the live animal; the latter is a rarity for many field guides, as land snail photography requires considerable skill and patience. The species accounts provide a general description of the shell characters, notes on the range, and where known, the habitat. The account also provides comments on how the shell can be distinguished from allied species. A common name has been provided; this is considered to be a useful addition, as many students and non-specialists find a common name easier to remember at the start of their studies.

There are a variety of different methods to assist the user in the techniques of identification. There is a simple key to families followed by keys to groups of some of the more difficult groups such as the Family Streptaxidae. At the beginning of each family information on identification characters, distribution and general biology of the animals is given. The colour tags on the sides of pages are an excellent addition make it easier to find the sections where each family account is presented without resorting to the index.

The quality of production is excellent. The pages are of good quality, with a paper, which whilst glossy for good production of the colour work, is not too glossy to make reading difficult. The book is well bound, and feels like it will withstand many years of heavy handling. From my knowledge of the fauna, the colour balance on the plates is excellent, and has not suffered the fate of other books, presumably due to close liaison between the author and the printers. The quality of the illustrations is excellent, with good depth of field on the photographs, many live animals and well shaded line drawings showing the three dimensional nature of the shells. The dot distribution maps generated from Museum collections and field collecting programmes show the nature of the distributions of each species and further comments are provided on the significance of this data.

The last handbook to the non-marine molluscs of southern Africa was produced in 1939, and did not illustrate all the species, so this new book is a much-needed addition to the series of field guides to the fauna of KwaZulu Natal. It provides a synopsis of current information on the biology, geology and history of studies of Molluscs in Southern Africa, and as such it is a guide that is likely to stand the test of time, reflecting the many years of experience that the authors have put into the production.

Mary Seddon  
Ben Rowson

# CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

## REPORT OF THE COUNCIL 2004

### *Council Positions*

Dr J M Light began her second year as President of the Society. The following Society Officers were elected: Hon. General Secretary Miss R E Hill, Hon. Treasurer Mr P U Buckle, Hon. Membership Secretary Mr M D Weideli, Hon. Editor (*Journal*) Dr P G Oliver, Hon. Editor (*Mollusc World*) Mr I J Killeen, Hon. Marine Recorder Dr J M Light, Hon. Non-Marine Recorder Mrs G A Holyoak, Hon. Conservation Officer Dr M J Willing and Hon. Programme Secretary Mr R Boyce. New Ordinary members of Council were Prof R A D Cameron, Dr R C Honnor and Mr P Topley. Mrs A J Millar, Ms J E Reynolds and Mrs C M Street began their second year and Dr D C Aldridge, Mr J E Llewellyn-Jones and Dr M B Seddon began their third year. Dr A T Sumner continued to be co-opted.

### *Publications*

Three issues of the *Journal of Conchology* (Volume 38: 2-4) and three issues of *Mollusc World* (Numbers 4-6, March, July and November) were published. *Journal of Conchology* Special Publication No. 3: Molluscan Biodiversity and Conservation, edited by Ian J Killeen and Mary B Seddon was published in July 2004 for sale to members. The Society also published the Annual Programme Card and the Members' Guide. Improvements to the Society's website [www.conchsoc.org](http://www.conchsoc.org) continued.

### *Society Display Boards*

The Conchological Society display material was in use during the summer months, from June to October 2004, at an exhibition entitled "Seashells on the Seashore", staged by the Booth Museum, Dyke Road, Brighton. This large special exhibition featured seashells from around the world, together with a large content of shell artefacts. Members of the public were invited to loan items made from shells for inclusion in the exhibition, and many took the opportunity to loan items for exhibition. The exhibition included a large number of shell artefacts loaned by Mr P.T.Wimbleton, the Society's Exhibits Coordinator, at the request of the museum. The Conchological Society's Display Material was displayed on museum wall panels, obviating the need for the use of the Display Boards.

At the same time as the Brighton Exhibition, a second exhibition was staged by the Exhibits Co-ordinator. This was at Emsworth Museum, Hampshire, for the month of June 2004. The exhibition was entitled "See Shells", and featured exotic foreign marine and British marine, land, and freshwater shells, with a display cabinet of articles carved from Mother-of-Pearl. As the Society's display material was already in use at Brighton, the Exhibits Co-ordinator produced some exhibition text wall panels, providing details of the Conchological Society for G.B. & I, for display at this exhibition.

In the Autumn of 2004, Dr Light requested the Exhibits Co-ordinator to provide an up-dated progress report on the use of the Display Material / Boards, for consideration of Council.

Following discussion of the Report, Council for the Society requested Mr Buckle and Mr Wimbleton, to consider some ideas for the content of a membership recruitment poster as a more convenient advertising medium than the Display Boards



*Other Council Matters*

Six Council meetings were held in another very active year for the Society. Amongst the issues considered by Council were: Society insurance renewal, Data Protection Act compliance, a *Helix pomatia* project, a meeting for young people in Cardiff as part of National Science Week, setting up a working group to consider the remit of the Conservation Committee including extending it to cover recording issues, production of a Privacy and Security Policy, reducing printing costs of Society publications, Society subscription increases, the proposed Garden Mollusc survey, a proposal for internet only subscriptions, Biodiversity Action Plan revisions, and regional representation of the Society.

One Research Grant was awarded to Harriet Wood and Jennifer Gallichan to visit the Dautzenberg Collection in Brussels for a 10-day period in order to research and image type material from Cesar-Marie-Felix Ancey for a project on New Molluscan Names Introduced by Ancey.

I would like to thank all members of Council and Society volunteers for their contributions during the year, and generous donations and legacies received.

R E Hill  
Hon General Secretary

## PROGRAMME SECRETARY'S REPORT - APRIL 2005

The programme for 2004 consisted of six indoor meetings held at the Natural History Museum in London and two indoor meetings elsewhere, nine field meetings and one indoor workshop.

**Indoor meetings:** Lectures at indoor meetings were given by Richard Preece (Land snails from the islands of the Tristan da Cunha group (South Atlantic)), Diana Reynell (Shells in art: restoration work), Roy Anderson (Slugging it out - problems in naming slugs), Pryce Buckle (Effects of population density on growth in *Eobania vermiculata*) (short talk), John Llewellyn-Jones (Changes in the littoral mollusca of the Scilly Isles) (short talk), David Long (Molluscs found on trips to Switzerland and the Picos de Europa (Spain)) (short talk), Adrian Sumner (Non-marine molluscs of Coll, Tiree and Colonsay) (short talk), Evelyn Moorkens (News from Ireland - LIVE!!), and John Llewellyn-Jones (Sea food and eat it).

Additional indoor meetings were held during National Science Week. One of these was a children's event at the National Museums and Galleries of Wales in Cardiff and the other was an open event consisting of two talks and an identification session at the Eric Liddell Centre in Edinburgh.

**Field meetings:** were held at the following venues: Hunthouse Wood, Worcestershire (Leader: Ron Boyce), Dorset (marine meeting, Leader: Lin Baldock), Branscombe, Devon (Leader: Keith Alexander), Sandwich, Kent (Leader: Eric Philp), New Forest, Hampshire (Leader: Martin Willing), Wyre Forest, Worcestershire (Leader: Harry Green), Linch Hill, Windrush Valley, Oxfordshire (wetland meeting, Leader: Alison Hopewell), North York Moors (Leader: David Lindley) and Syon Park, Brentford, London (Leader: Simon Terry).

The Society's eighteenth Molluscan Workshop was on the subjects of Eocene microfossils from the Paris Basin and slug identification by dissection, held at Judith Nelson's home in Woking, Surrey (tutors: Adrian Rundle and Brian Eversham).

The Society is grateful to all those people who contributed to the above programme, as speakers, field meeting leaders, and meeting and workshop organisers and tutors.

Ron Boyce  
Hon. Programme Secretary

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN &  
 IRELAND ACCOUNTS FOR THE YEAR ENDED YEAR YEAR  
 ENDED 31 DECEMBER 2004

STATEMENT OF FINANCIAL ACTIVITIES

	Note	2004	2003
<b>Incoming resources</b>			
Fees and subscriptions		£10,178	£10,411
Investment income	1	£5,368	£5,454
Income from activities for generating funds		£335	£474
Other incoming resources		£1,732	£38
Donations and legacies		£4,784	£50
<b>Total incoming resources</b>		<b>£22,397</b>	<b>£16,427</b>
<b>Expenditure</b>			
Publications costs		£17,802	£18,504
Stationery and postage		£527	£1,347
Meetings costs		£726	£1,705
Sundry expenses and fees		£938	£544
Grants	2	£0	£0
Depreciation		£0	£600
<b>Total expenditure</b>		<b>£19,993</b>	<b>£22,700</b>
<b>Net incoming/(outgoing) resources</b>		<b>£2,404</b>	<b>(£6,273)</b>
<b>Gains / (Losses) on revaluation</b>		<b>£2,634</b>	<b>£2,074</b>
<b>Net movement in funds</b>		<b>£5,038</b>	<b>(£4,199)</b>
<b>Fund balances brought forward</b>		<b>£107,023</b>	<b>£111,222</b>
<b>Fund balances carried forward</b>		<b>£112,061</b>	<b>£107,023</b>

BALANCE SHEET AT 31<sup>ST</sup> DECEMBER 2003

		2004	2003
<b>Fixed Assets</b>			
Investments at market value	3	£81,617	£78,983
<b>Total fixed assets</b>		<b>£81,617</b>	<b>£78,983</b>
<b>Current Assets</b>			
Debtors	4	£260	£635
Cash at bank and in hand		£40,100	£35,013
<b>Total current assets</b>		<b>£40,360</b>	<b>£35,648</b>
<b>Short term creditors</b>	5	<b>£9,575</b>	<b>£7,297</b>
<b>Net current assets/(liabilities)</b>		<b>£30,785</b>	<b>£28,351</b>
<b>Total assets less current liabilities</b>		<b>£112,402</b>	<b>£107,334</b>
<b>Provisions for liabilities</b>	6	<b>£341</b>	<b>£311</b>
<b>Net assets</b>		<b>£112,061</b>	<b>£107,023</b>
<b>Unrestricted income funds</b>		<b>£112,061</b>	<b>£107,023</b>
<b>Total funds</b>		<b>£112,061</b>	<b>£107,023</b>



## NOTES TO THE FINANCIAL STATEMENTS

## ACCOUNTING POLICIES

**General**

- These statements have been prepared in accordance with Financial Reporting Standard for Smaller Entities (FRSSE) and the Charities SORP (Statement of Recommended Practice)
- Investments are valued at market value on 31<sup>st</sup> December.
- No trustee has received any remuneration during the current or previous year. Expenses incurred on behalf of the Society have been reimbursed.

**Funds**

- All Society funds are unrestricted funds
- The accounts include transactions, assets and liabilities for which the Charity can be held liable.

<b>Note 1. Investment income from:</b>	<b>2004</b>	<b>2003</b>
Stock listed on recognised stock exchange	£5,009	£5,127
National Savings Income Bond	£359	£327
Total	<u>£5,368</u>	<u>£5,454</u>
<b>Note 2. Grants awarded:</b>	<b>2004</b>	<b>2003</b>
No suitable applications received	£0	£0
<b>Note 3. Investments:</b>	<b>2004</b>	<b>2003</b>
Market value at beginning of year	£78,983	£76,909
Net gain/(loss) on revaluation	£2,634	£2,074
Market value at end of year	<u>£81,617</u>	<u>£78,983</u>
<b>Note 4. Analysis of debtors:</b>	<b>2004</b>	<b>2003</b>
Tax debtors	£260	£635
<b>Note 5. Analysis of creditors and accruals:</b>	<b>2004</b>	<b>2003</b>
Publications accruals	£7,055	£4,146
Meetings costs	£1,000	£1,900
Subscriptions in advance	£1,520	£1,251
Total	<u>£9,575</u>	<u>£7,297</u>
<b>Note 6. Provision for liabilities</b>	<b>2004</b>	<b>2003</b>
Marine fieldwork provision	£341	£311

Pryce Buckle  
Honorary Treasurer

N. Light  
Honorary Examiner

## RECORDER'S REPORT: NON-MARINE MOLLUSCA

The following new vice-county records have been confirmed since the last Report (*J. Conch.* 38: 480-483, 2004). Unless stated otherwise all were confirmed from specimens collected during 2004. The report is a collation of new verified records received by the Society's Non-marine Recorder, not a review of the published literature. For continuity nomenclature follows Kerney (1999); a revision of the list of the land and freshwater molluscs of Great Britain and Ireland is in preparation.

- West Cornwall** (1): *Limax flavus*, Isles of Scilly (SV9010), J. Chatfield; *Arion owenii*, Tuckingmill (SW6540), G.A. Holyoak, 1999.
- Dorset** (9): *Lymnaea fuscus*, West of Sopley (SZ1497), D.T. Holyoak, G.A. Holyoak & M.J. Willing.
- Surrey** (17): *Corbicula fluminea*, banks of River Thames (TQ17), O. Whalley.
- Middlesex** (21): *Corbicula fluminea*, banks of River Thames (TQ17), O. Whalley.
- Buckinghamshire** (24): persistent alien – *Papillifera papillaris*, W of Burnham Beeches ((SU98), per J Ridout-Sharpe, conf. D.T. Holyoak.
- West Norfolk** (28): *Lymnaea fuscus*, East Dereham (TF91), G.A. Holyoak; *Vertigo geyeri*, nr East Dereham (TF91), G.A. Holyoak; *Vertigo angustior*, Holme-next-the-sea (TF7044), D. Howlett & R. Baker, 2002.
- Herefordshire** (36): *Physa acuta* seg., Bodenham Lake (SO5251), E. Pisolkar; *Gyraulus laevis*, Bodenham Lake (SO5251), E. Pisolkar, det. M.J. Willing.
- Caernarvonshire** (49): *Limax maculatus*, Moelyei Farm, Tregarth (SH5967), J. Bratton.
- Anglesey** (52): *Physa acuta* seg., Malltraeth Marsh RSPB Reserve (SH4571), conf. D.T. Holyoak; *Lymnaea fuscus*, Cors Bodeilo NNR (SH5077); *Limax maculatus*, Menai Bridge (SH5571); all J. Bratton.
- North Lincolnshire** (54): *Hygromia cinctella*, Market Rasen (TF1089), C. Smith per E.J. Redshaw.
- North-west Yorkshire** (65): *Lehmannia valentiana*, Castle Bolton (SE0391), A. Norris, det. A. Norris.
- Ayrshire** (75): *Limax maculatus*, Dundonald Castle, Dundonald (NS33), R. Anderson.
- Roxburghshire** (80): *Leiostyla anglica*, Whitlaw Wood (NT5013), A. Sommerville per A.T. Sumner.
- South Eubudes** (102): *Valvata piscinalis*, Loch Glencastle, The Oa, Islay (NR3044); *Gyraulus crista*, Ardnave Loch, Islay (NR2872); *Gyraulus albus*, Loch Finnlagen, Islay (NR3968); *Sphaerium corneum*, Loch Finnlagen, Islay (NR3968); all M.J. Willing.
- Clare** (H9): *Lymnaea fuscus*, Lough Bunney (R3897); *Boettgerilla pallens*, Spar gardens, nr Lisdoonvarna (R1398); *Dreissena polymorpha*, Lough Derg at Dooros (R7186); all G.A. Holyoak.
- Carlow** (H13): *Lymnaea fuscus*, W of Borris (S7150); *Planorbarius corneus*, W of Borris (S7150); both G.A. Holyoak.
- South-east Galway** (H15): *Lymnaea fuscus*, Tirneevin (M4001); *Planorbarius corneus*, Lough Derg at Portumna Bay (M8503); *Oxyloma sarsi*, River Shannon (N01) det. D.T. Holyoak, conf. R. Anderson, new to Ireland; *Arion owenii*, nr Caherglassaun Lough (M4106), conf. R. Anderson; *Perforatella subrufescens*, Garryland Wood (M4103); *Dreissena polymorpha*, Lough Derg at Rosmore Pier (R7943); all G.A. Holyoak.
- West Galway** (H16): *Bithynia leachii*, Lough Corrib, N of Knockferry (M2341); *Lymnaea fuscus*, Lough Nalawney, NW of Roundstone (L6941); *Planorbis carinatus*, Lough Corrib, N of Knockferry (M2341); *Anisus vortex*, Lough Corrib, NE of Oughterard (M1343); *Acroloxus lacustris*, Doonloughan Lough (L5744); *Catinella arenaria*, N of Galway (M23); *Vertigo geyeri*, S of Knock (L54); *Arion owenii*, E of Recess (L8747), conf. R. Anderson;

- Boettgerilla pallens*, Kylemore Abbey (L7558); *Limax cinereoniger*, NW of Ballynahinch Castle (L7547); *Lehmannia valentiana*, Kylemore Abbey estate gardens (L7358), conf. R. Anderson; *Ashfordia granulata*, NE of Oughterard (M1343); all G.A. Holyoak.
- North-east Galway** (H17): *Bithynia leachii*, Lough Corrib, SW of Luimnagh (M2941); *Lymnaea fuscus*, Lough Corrib at Annaghdown Pier (M2837); *Catinella arenaria*, NW of Galway (M33); *Arion flagellus*, Mountbellow Demesne (M6646), conf. R. Anderson; *Arion owenii*, W of Angliham (M2930), conf. R. Anderson; all G.A. Holyoak.
- Offaly** (H18): *Dreissena polymorpha*, River Shannon, W of Shannonbridge (M9625), G.A. Holyoak.
- Westmeath** (H23): *Lymnaea fuscus*, Lough Ree at Coosan Point (N0446), G.A. Holyoak.
- Roscommon** (H25): *Lymnaea fuscus*, Lough Ree at Galey Bay (M9558); *Gyraulus crista*, nr Lough Ree at Portrunny Bay (M9560); *Hippeutis complanatus*, Lough Ree at Portrunny Bay (M9560); *Milax gagates*, Mount Talbot Bridge (M8153); all G.A. Holyoak.
- East Mayo** (H26): *Arion owenii*, NW of Claremorris (M3376); *Zonitoides excavatus*, nr east bank of Cloon River (M1372); *Limax cinereoniger*, nr east bank of Cloon River (M1372); all G.A. Holyoak.
- Down** (H38): *Arion occultus*, Bank Lodge Wood, Ballywalter (J6367), R. Anderson, 2003 (*J. Conch.* 38: 341-353, 2004), a newly described species, new to Ireland.

This is my second year as the Non-Marine Recorder and again it seems to have been a particularly active year with over 50 new-vice county records. There are a number of noteworthy records the most significant being Roy Anderson's recent description of the new species *Arion occultus* which he discovered in Northern Ireland (*J. Conch.* 38: 341-353, 2004).

It was a surprise to find *Oxyloma sarsi* living in Ireland, since this species is otherwise known only from a handful of sites in eastern England, and it was similarly surprising to find *Vertigo geyeri* living in Norfolk. Fossil records in *The Atlas* show that *V. geyeri* was once quite widespread across central England but there was hitherto no evidence that it persists there today.

*Corbicula fluminea* has been found living in the River Thames by Oliver Whaley. This alien freshwater bivalve was initially discovered in Norfolk by Roy Baker in the 1990s so finds in the River Thames suggest that it is likely to spread further in future.

Martin Willing recorded four new vice-county records of freshwater species on Islay last year, which together with the remaining records show that there is still a lot of recording to be done.

Pryce Buckle has called attention to records of *Vertigo angustior* in West Norfolk (vc28) published by Ellis in the Recorder's Report (*J. Conch.* 23: 59-61) and the 1951 *Census of the distribution of British non-marine Mollusca* (*J. Conch.* 23: 171-245). The *Census* entry for *V. angustior* in vc28 is in italic text denoting that the record had not been 'verified' from specimens (*J. Conch.* 23: 171-245). However, Kerney did not list *V. angustior* for vc28 in the 1982 *Census* (*J. Conch.* 31:63-71). It has been accepted therefore that this unconfirmed record in the 1951 *Census* was deleted. In fact, hand-written notes (on the species record card) entered by Michael Kerney show that the original record of *V. angustior* in West Norfolk was based on a 1909 publication, and that he considered that there was 'no evidence that living examples were involved'. The specimens concerned are in the Kennard collection, NHM, London. The record remains and was published in *The Atlas* (Kerney, 1999: 101), plotted as a fossil record in grid square TF64 at Hunstanton. Fossil distributions are not included in the vice-county record system, only live or contemporary populations. Thus the 2002 record by Howlett and Baker at Holme-next-the sea (TF7044) is the first confirmed occurrence of living *V. angustior* in West Norfolk.

Pryce Buckle is also thanked for locating a record of *Anisus vortex* in West Galway (H16) published in 1971 (Kerney, *J. Conch.* 27: 444-448). However this record was excluded



from the 1982 *Census* (Kerney, *J. Conch.* 31:63-71). Hand-written notes entered by Michael Kerney on the species record card of the H16 record, state 'I now have serious doubts about this record - omit' [the record], this was based on a single specimen. The 2004 record of *Anisus vortex* from Lough Corrib is thus the first confirmed record for H16.

Dr Mary Seddon is thanked for drawing attention to the publication in 1998 by Minchin and Moriarty (*Irish Naturalist Journal* 26: 38-42) on the distribution of *Dreissena polymorpha* in Ireland, which records naturalised populations in the River Shannon and Lough Derg. However, the first confirmed record of *D. polymorpha* in Ireland was published by Kerney (*J. Conch.* 36: pp 59-60) in 1998. This record was based on specimens received from D. Minchin collected from the River Shannon at Birdhill in north Tipperary (H10) in 1997. Although Kerney mentioned other records these were not published as part of the vice-county census. This followed a long tradition that new vice-county records should be based only on specimens confirmed by the non-marine Recorder, not necessarily the oldest report. Potential new vice-county records from other publications have also been excluded from the Recorders' Reports unless specimens have been submitted.

In 2004, the Biological Records Centre (BRC) made the 1999 *Atlas* data available through the NBN (National Biodiversity Network) Gateway. You can 'log-on' and use the site at [www.searchnbn.net](http://www.searchnbn.net). More mollusc data will be added in future by BRC, supported by the NBN and DEFRA. Some of this data has already become available through the NBN Gateway enabling full use of the records.

Geraldine A. Holyoak

## RECORDER'S REPORT: MARINE MOLLUSCA

The year under review has been a relatively quiet one on the field recording front. On the other hand new initiatives underway and the establishment of the Conservation and Recording Committee (CRC) are intended to prompt action to integrate those two important strands of the Society's work and establish protocols in those areas of activity, in order to address the challenges of Biodiversity-directed projects and electronic data exchange in a wider arena beyond this Society.

Why do we gather mollusc records? Nowadays, amongst several, three motives might be curiosity, conservation interest, or commercial purposes. Whatever the driving force, the data generated are important for supporting conservation biology and environmental management and I believe it is incumbent on this Society to find ways to make our data accessible. I am pleased to report that the marine records, initially computerised in Recordit format, have been transferred to Recorder 2002. This database needs to be checked for errors to ensure that a clean database of marine mollusc records finally finds its way into the wider recording community where it can be used for conservation and educational purposes. This will include making the information available on the NBN Gateway which was officially launched in 2004 and it currently holds over 17 million records from 120 separate datasets. One of the issues that I wish to address through the CRC is how to develop a policy on data access in order to make our marine records as widely available as possible whilst maintaining control as to who can see the data and in what form. Via the Gateway the Society can publish up-to-date distribution maps and, given, that publication of maps and atlases for a group generally leads to an increase in recording in order to 'fill the gaps' this might invigorate the recording activities. Although we have computerised some of our marine data, these represent a minority of records held by the Society. Another task to address is the input of uncomputerised data into Recorder 2002 with the involvement of members of this Society in the keying in of the records. Finally, a substantial bank of data is held by Sea Area Representatives. I am currently undertaking an Audit of those archives with the intention of assembling those records for computerisation. Again, the voluntary assistance of Society members can help this to be achieved.

And what of new records for the year? A large specimen (>30cm in length) of *Aplysia depilans* was found on Tresco sandflats (SV917138) by Celia Pain and John Llewellyn Jones in October 2004. There is a questionable record for the species from the the north coast of St Mary's in 1983, but this is the first authenticated record from SA 19 (confirmed by Alan Bebbington). *Atrina fragilis* is a protected species (listed under Section 9 of the Wildlife and Countryside Act, 1981). Eight individuals have been found at Plymouth Hoe over the past 14 months (principally in July 2004) within a 10,000m<sup>2</sup> area. This find has been collectively attributed to the efforts of MarLIN Marine Life Signpost scheme, the Marine Conservation Society Fanshell Awareness Programme, Seasearch and the Marine Biological Association. Attempts are now under way to secure some protection for the site which encompasses the group of *Atrina*.

From Ireland Julia Nunn reports the following new records: *Embletonia pulchra* from St Johns Point, Donegal new to SA 34, *Calyptraea chinensis* from Strangford Lough new to SA 28 and *Runcina ferruginea* from Mulroy Bay new to SA 33. This latter is the most northerly record in the British Isles, the species only being recorded from Plymouth, and SA 37 in southwest Ireland. Her fieldwork has also yielded a third site for *Truncatella subcylindrica* in Ireland, at Finavarra in Co Clare. Further to my report for 2003, *Osilinus lineatus*, of particular focus in connection with global warming studies continues to move up the eastern seaboard of Ireland. A single specimen was found in the north part of Strangford Lough, and now found for the first time living (1856 record, not known if

live) on the south outer Ards peninsula.

During 2004 my time spent on determination and confirmation of specimens other than potential new records increased significantly. Such enquiries now emanate from a wide spectrum of workers in matters relating to Northeast Atlantic marine molluscs and I intend to explore ways of involving the membership in routine identification of specimens, as part of the Society's commitment to help and encourage novices and new members. With this in mind I intend to compile a register of individuals with expertise in particular taxonomic areas of relevance and would welcome offers from members who feel they have skills to offer.

I thank those who have continued to support recording activities in 2004, especially Tom Clifton, John Llewellyn Jones, Julia Nunn and Celia Pain.

Jan Light



## REPORT OF THE HON. CONSERVATION OFFICER 2004–2005

Selected key items from the 2004 - 05 year are summarised below.

### Advice and help

Has been given to many individuals and organisations and some examples include:

- The Sussex Wildlife Trust was given advice on management plan proposals for Burton Mill Pond a site supporting the largest known population in Sussex of the BAP Priority Species *Vertigo moulinsiana*.
- The Society was able to provide help and advice regarding the survey of lands designated as a nature reserve at Eton College.
- Specimen identification confirmations were undertaken for several members and organisations (e.g. the Environment Agency, Exminster);
- The RSPB was given help in assessing the non-marine molluscan populations of reserves on Islay, Western Scotland.
- Scottish Natural Heritage was given assistance in the preparation of a leaflet providing conservation guidance and advice to Islay landowners with populations of the BAP Priority Species *Vertigo geyeri* on their land.

### British Wildlife

The production of a molluscan wildlife report for this journal has continued with the publication of three reports throughout the year in April 2004, August 2004 and February 2005. The Conservation Officer has used this column to publicise selected aspects of work undertaken by the Society.

### Invertebrate Link (formerly J.C.C.B.I.) and The Invertebrate Conservation Trust (Buglife)

Membership of the Committee continues providing valuable contacts with other organisations. Member organisations of Invertebrate Link present annual summaries of their organisation's conservation work throughout the year and the Conservation Officer tabled a short summary of the Society's work at the October 2004 meeting.

On 3 April 2004 the Conservation Officer presented a talk titled 'Molluscs: A Wingless View' at the Fourth Invertebrate Link conference, which considered issues relating to the concept of 'favourable conservation status' in relation to invertebrate populations. A summary of the conference proceedings will appear in Mollusc World.

### The Fourth Quinquennial Review of Schedules 5 & 8 of the Wildlife and Countryside Act, 1981

In late 2002 it became known that the Joint Nature Conservation Committee (JNCC) had recommended *Helix pomatia* for addition to Schedule 5 of The Wildlife & Countryside Act. At the end of 2004 the DEFRA published their long overdue response to the JNCC proposals for revision of Schedules 5 & 8 of The Wildlife & Countryside Act. The DEFRA response revealed that *H. pomatia* had been placed into a 'neutral' category (together with 5 species of fish). DEFRA invited further responses by early April 2005; JNCC advised that the Conchological Society resubmit their earlier proposals to DEFRA which was duly undertaken by the deadline.

In 2004 the Conservation Officer, assisted by other Society members, embarked upon an initiative to try to gather more information on the snail in 2004/05 particularly in its three core areas, the Cotswold and Chiltern Hills and the North Downs. Requests for information published in Mollusc World and British Wildlife have produced a good response from non-members but only a single reply from a member of the Society. Material is still being collected and a summary report will appear in a future Society publication.

### Mollusc World

The Conservation Officer has contributed articles to editions 4 and 6 of the publication.

### Biodiversity Matters

A meeting of the UK BAP Terrestrial Mollusc Steering Group (dealing with the BAP Priority Species *Vertigo geyeri*, *V. genesii*, *V. angustior*, *V. moulinsiana* and *Catinella arenaria*) took place at , North Devon in August 2004. Five Society members attended the meeting.

- A meeting of the UK BAP Freshwater Mollusc Steering Group (dealing with the BAP Priority Species *Anisus vorticulus*, *Sementina nitida*, *Myxas glutinosa*, *Pseudanodonta complanata* and *Pisidium tenuilineatum* and the BAP Species of Conservation Concern *Gyraulus acronicus*) took place at Reading in February 2005 and was attended by four Society members. Both Steering Group meetings focused upon the current UK BAP Priority Species Review and the BAP Priority Species Targets review. Reports summarising both BAP Steering Group Meetings will appear in a future issue of Mollusc World.
- In late 2004 the Conservation Officer was invited by Buglife to act as non-marine Coordinator for the review of the UK BAP Priority Species. A series of articles in Mollusc World explained the background to the review and in issue 6: 10, members were invited to obtain an explanatory leaflet detailing review criteria and submit proposals to be considered by the Society. Members of Council and the newly convened Conservation & Recording Committee were also encouraged to become involved. At the time of writing this annual report the recommendation submission process was still being completed; the final refinement of the proposals will continue into the 2005 – 2006 business year. The marine BAP Priority Species were considered by a separate review and details were forwarded to The Hon. Marine Recorder who was liaising with the Review committee on behalf of the Society.

### Associations with other organisations

At a field meeting in June 2004 Society members and guests visited a number of ponds in the Brockenhurst area of the New Forest. The focus of the meeting was to launch the Society's involvement with New Forest Ponds Project, particularly with regard to better understanding the distribution and ecology of the rare freshwater snail *Omphiscola (Lymnaea) glabra* in the Forest. A report of the meeting appears in Mollusc World 6: 22-23.

The Conservation Officer continues to attend conservation committee meetings of The Sussex Wildlife Trust. He wrote an article on rare freshwater Mollusca living in floodplain grasslands in Sussex for the 'Adastra' magazine (Adastra 2004: 16 - 19, published February 2005: Sussex Biodiversity Record Centre, Henfield, West Sussex) and presented at the annual Biological Recorders Seminar of the Trust. The article drew attention to the work of the Conchological Society.

In February 2005 the Conservation Officer gave a couple of talks introducing non-marine Mollusca and a case study of conservation work on one particular species to Birkbeck College's Ecology & Conservation Society; the event provided a opportunity to publicise the work of the Society to potential new members.

### Formation of the Conservation & Recording Committee

After Council discussions during 2004 on the remit and membership of a proposed Conservation & Recording Committee, the new committee was duly approved in early 2005. The Committee includes the Marine and Non-marine Recorders, Conservation Officer and four other members. The members of the newly formed committee therefore include Jan Light Geraldine Holyoak, Martin Willing, Brian Eversham (Chair), Mary Seddon, Michael Weideli and Robert Cameron. The new Committee will report annually to Council.

M.J. Willing  
Hon. Conservation Officer

## HEALTH AND SAFETY REPORT, FIELD SEASON 2004.

There were nine Conchological Society field meetings in 2004, as outlined on the Programme Card for the year. Risk Assessment documentation was drawn up for all these meetings and there are no incidents to report.

Jan Light

## MEMBERSHIP SECRETARY'S REPORT FOR 2004

Membership of the Society at the end of 2004 was 336. This includes Life Members, Honorary Members, Ordinary Members, Family Members, Student Members and Institutions. There were 22 new members in the year, but 20 members resigned or lapsed through non-payment, giving a net gain of 2 members for the year.

During the year there were 80 subscribers to the Journal of Conchology which is the same as in 2003.

Mike Weideli  
Hon. Membership Secretary





## INSTRUCTIONS TO AUTHORS

Manuscripts should be sent to:

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ANNA.HOLMES@NMGW.AC.UK

**PAPERS** Two copies of text and illustrations should be submitted; one set of illustrations must be good quality originals. Authors should refer to *New Instructions to Authors* in 37 part 1. Authors are reminded of the high cost of printing and therefore are expected to write concisely and to make maximum use of page size when designing artwork and tables.

**COMMUNICATIONS** These are intended to be short notes of an original nature which do not merit the treatment of a full paper. *Communications* do not normally contain any figures, tables or plates and should conform in style to that of recent issues of the *Journal*.



# Journal of Conchology

Vol. 38, Part 6, November 2005

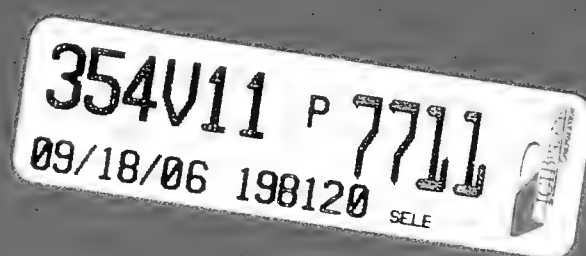
## Contents

### PAPERS

	PAGE
ANDERSON R. An annotated list of the non-marine mollusca of Britain and Ireland.	607
CIANFANELLI S., MANGANELLI G. & GIUSTI F. New data on the systematics and distribution of the oxychiline zonitid <i>Mediterranea depressa</i> (Sterki, 1880) in Italy (Gastropoda: Pulmonata: Zonitidae).	639
GITTENBERGER E. & UTT DE WEERD D.R. <i>Babylonia</i> and <i>Zemiropsis</i> (Gastropoda: Caenogastropoda: Babyloniidae), anatomy, shell morphology, distribution and DNA.	649
GARRIDO J.A., ARREBOLA J.R. & BERTRAND M. Extant populations of <i>Orculella bulgarica</i> (Hesse, 1915) in Iberia.	653
CALADO G., ORTEA J. & CABALLER M. A new species of the genus <i>Flabellina</i> Voigt, 1834 (Mollusca: Nudibranchia) from the Cape Verde Islands.	663
HOLMES A.M., OLIVER P.G. & SELLANES J. A new species of <i>Lucinoma</i> (Bivalvia: Lucinoidea) from a methane gas seep off the southwest coast of Chile.	673
HORSÁK M. & HÁJEK M. Habitat requirements and distribution of <i>Vertigo geyeri</i> (Gastropoda: Pulmonata) in western Carpathian rich fens.	683
KILLEEN I.J. Studies on the round-mouthed whorl snail <i>Vertigo genesii</i> (Gastropoda: Vertiginidae) in northern England: observations on population dynamics and life history.	701

### COMMUNICATIONS

CUCHERAT X. & BOCA F. <i>Cochlicopa nitens</i> (Cochlicopiidae) living in northern France.	711
CUCHERAT X. <i>Vertigo substriata</i> & <i>Vertigo angustior</i> in northern France.	711
GITTENBERGER E. & BANK R.A. The genus <i>Pholeoteras</i> Sturany, 1904, in Greece (Gastropoda, Caenogastropoda, Cyclophoridae).	713
SEDDON M. & PICKARD M. Another Mediterranean land-snail found in UK.	714
BOOK REVIEW	715
PROCEEDINGS	717



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